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Industry-University R&D Collaboration and Innovative Performance of Greek Manufacturing Firms in Times of Crisis:

Do Interactions of Knowledge Flows and Knowledge Stocks Matter?

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The topic addressed: research questions

- The topic
  - explore the links between firm innovation and collaboration with universities in times of crisis,
  - taking also into account possible interactions between knowledge flows and knowledge stocks.

- Research questions
  - How do the potential effects of Industry-University R&D collaborations on innovation evolve as the crisis deepens?
  - How does the interaction between knowledge stocks and flows affect innovative performance of manufacturing firms in Greece?
    - Do the knowledge flows have a similar or a differentiated effect on product innovation, when firms have high levels of knowledge stocks as when they have low levels of knowledge stocks?

Motivation: a crisis-hit economy, Greece

- The economic crisis that burst in 2008 has created a far more turbulent and difficult environment for Greek economy and Greek firms.
- Over the six-year period 2008-2013, Greece lost about 25% of its gross value added, and unemployment increased to the level of 27%.
- Efforts for innovation were weakened, thus affecting the overall innovation performance of the Greek productive system.
- Need for an "innovating out of the crisis" growth strategy

Motivation: on the role of industry-university knowledge flows

- Internal capabilities and openness towards knowledge sharing are important for upgrading innovative performance (Caloghirou et al., 2004)
- Collaboration of firms with universities and research institutes may spur the creation of radical, next-generation innovations (Belderbos et al., 2004)
- Firm innovation strategies tend to be more effective when they are characterized by the existence of any complementarity between internal knowledge investment and external knowledge acquisition (Cassiman & Veugelers, 2006)
- Several studies demonstrate the significant role that existing knowledge stocks play in shaping innovativeness (e.g. Lee, 2010; Wu & Shanley, 2009)
- while other studies highlight the beneficial effects of university knowledge flows on firm innovation (Agrawal & Henderson, 2002; Agrawal, 2006; Henard & McFadyen, 2006; Monjon & Waelbroeck, 2003; Tether, 2002).

Contribution

- These studies, however, largely neglect the combined role of knowledge stocks and university knowledge flows on firms' product innovation.
- Such evidence is important for understanding the mechanism by which the mix or the balance between exploiting knowledge stocks and exploring knowledge flows may determine the innovative performance of firms.
- Recently only a very limited number of recent works (Roper & Hewitt-Dundas, 2015 - RP; Al-Laham et al. 2011- ICC) have examined the role of interactions between knowledge flows and knowledge stocks
- We integrate the role of Industry-University R&D collaborations into a more generic context of knowledge flows and knowledge stocks
- We give emphasis on the erosive nature of the economic crisis

Data used

- 2 extensive surveys
  - In the largest Greek firms at the national and regional level (in terms of employment)
  - In two waves with a structured questionnaire
  - CATI approach, but also some face to face interviews

1st wave: Burst of the crisis **2nd wave: Peak of the crisis**

- Period: 2011
- Total number of firms: 2025

- Period: 2013
- Total number of firms: 2048

1500 firms have participated in both waves

❑ 524 manufacturing firms

Methodology

- Panel probit regression to estimate the driving forces of the probability of firms to introduce product innovation
  - *Product Innovation = f {Industry-University- R&D Collaboration; Crisis Deepening Dummy; Exporting; Education; Age; Low Cost Strategy; Differentiation Strategy; Liquidity Constraints; Competition Intensity; Training; Size}*
  - Independent variables of primary interest
    - **Crisis deepening dummy**
    - **Knowledge flows variable**: industry-university R&D collaboration
    - **Knowledge stocks variables:** exporting; education; age of the firm
  - Control variables
    - low cost strategy; differentiation strategy; liquidity constraints; competition intensity; training; size; sector dummies

Dependent variable

- **Innovation**
  - ***Product Innovation*:** Has the company introduced any new or improved products over the 3-year period covered by the survey (no=0; yes=1)

Frequencies for dependent variable		
	Obs	Yes
Product innovation (2011)	520	59.8%
Product innovation (2013)	520	49.0%

Independent variables:

- Crisis deepening dummy:
  - 0 for the year 2011 and 1 for the year 2013.
- Knowledge flows variables
  - *Industry-University R&D collaborations*: To what extent does your company use universities and research centers as a source of knowledge in the context of joint R&D projects (not at all: 1, …. 5: to a great extent)
- Knowledge stocks variables
  - *Exporting*: dummy variable that takes the value 1 when the firm is an exporting firm and zero otherwise.
  - *Educational level*: share of employees with a university degree (above 75% of the distribution)
  - *Age of the firms*: natural logarithm of age

Independent variables:

- Control variables
  - Strategic factors
    - Low cost strategy: does the company produce standardized products/services for mass markets? (No=0; yes=1)
    - Differentiation strategy: does the company produce differentiated products/services? (No=0; yes=1)
  - Liquidity constraints
    - Liquidity constraints - bank credit: to what extent does your company face liquidity constraints due to restricted access to credit lines?(Not at all: 1, …. 5: to a great extent)
    - Liquidity constraints - trade credit: to what extent does your company face liquidity constraints because of your suppliers and/or customers liquidity problems?(Not at all: 1, …. 5: to a great extent)

Independent variables:

- Competition pressure
  - Price competition: to what extent does your company face pressure from cost based competitors? (Not at all: 1, …. 5: to a great extent)
- Training
  - Training Programs: Does your company perform corporate training programs? (no=0; yes=1)
- Firm size:
  - Natural logarithm of the number employees
- Sector dummies:
  - for 9 manufacturing industries (Food and Beverages, Textile, Paper and Publishing, Chemical products, Plastic/ Elastic Industry, Non metallic Industry, Basic metals, Machine and machinery equipment, Furniture, and Rest of manufacturing sectors)

Determinants of product innovation

Dependent Variable Product Innovation	Model 1
Industry-University R&D collaborations	**0.531** (0.261)**
Industry-University R&D Collaborations_square	**-0.082* (0.048)**
Crisis deepening dummy	**-0.468*** (0.124)**
Exporting dummy	0.285 (0.175)
Education	-0.115 (0.328)
Age	0.049 (0.11)
Low cost strategy	0.015 (0.142)
Differentiation Strategy	**0.506*** (0.141)**
Liquidity constraints_Banks	-0.029 (0.055)
Liquidity constraints_Supply Chain	0.065 (0.066)
Price based competition	0.086 (0.055)
Training	**0.32* (0.168)**
Size	**0.245*** (0.073)**

Notes: The estimations include sector dummies. Marginal effects are presented

***, **, * denote significance on p<1%, 5%, 10%. Standard errors are reported in parentheses.

Model 1: Discussion of results

- Industry-university R&D collaborations play an important role in shaping firm innovation taking the form of an inverted U. Although a moderate level of university knowledge flows facilitates firms to innovate, a very large scale of collaborative R&D projects do not necessarily lead to increased innovation gains (Berchicci, 2013 – RP).
- Knowledge stocks -exporting, age, education- do not matter. It seems that crisis erodes the effectiveness of knowledge stocks on innovation output. As it has been already pointed in the case of turbulent knowledge environments (Barnett & Sorenson, 2002 - ICC) in abrupt times too, it is necessary for firms to refresh their knowledge base in order to increase their organizational survival chances.
- Crisis deepening has a clear negative and strong impact on the probability of firms to innovate. This finding is in the same line with Paunov (2012 - RP) who provides empirical evidence that the recent global crisis caused significant innovation project discontinuations due to greater financial constraints.
- When firms develop training programmes for their employees, pursue differentiation strategies and become larger their innovative chances improve.

Models with interaction terms of knowledge flows and knowledge stocks

- Interaction of the Industry-University R&D Collaboration variable with the dummy variables of Crisis, Exporting, Education and Age (Young) dummies :
- **Model 2:** Industry-University R&D Collaboration*Crisis and Industry-University R&D Collaboration*(1-Crisis), where Crisis value is 1 for 2013, (deepening of the crisis) and 0 for 2011, (burst of the crisis).
- **Model 3:** Industry-University R&D Collaboration*Exporting and Industry-University R&D Collaboration*(1-Exporting), where Exporting value is 1 for exporting firms and 0 otherwise.
- **Model 4**: Industry-University R&D Collaboration*Education and Industry-University R&D Collaboration*(1-Education), where Education value is 1 if the firm's percentage of highly educated employees is above the 75th percentile of the distribution on the education variable and 0 otherwise.
- **Model 5**: Industry-University R&D Collaboration*Young and Industry-University R&D Collaboration*(1-Young) for model 5, where Young value is 1 if the firm is up to 10 years old, and 0 if it is older than 10 years.

Dependent Variable Product Innovation	Model 2
Industry-University R&D collaboration*Crisis Deepening	**0.135* (0.073)**
Industry-University R&D collaboration*(1-Crisis Deepening)	0.078 (0.076)
Exporting	0.218 (0.168)
Education	-0.287 (0.313)
Age	0.003 (0.106)
Low cost strategy	0.03 (0.138)
Differentiation Strategy	**0.481*** (0.137)**
Liquidity constraints-Bank credit	-0.07 (0.052)
Liquidity constraints-Trade credit	0.02 (0.063)
Price based competition	0.079 (0.053)
Training	**0.341** (0.161)**
Size	**0.264*** (0.071)**

Notes: The estimations include sector dummies. Marginal effects are presented
***, **, * denote significance on p<1%, 5%, 10%. Standard errors are reported in parentheses.

Dependent Variable Product Innovation	Model 3
Industry-University R&D collaboration*Exporting	0.072 (0.065)
Industry-University R&D collaboration*(1-Exporting)	**0.197* (0.116)**
Crisis deepening dummy	**-0.412***(0.122)**
Education	-0.13 (0.325)
Age	0.04 (0.11)
Low cost strategy	0.033 (0.142)
Differentiation Strategy	**0.518*** (0.14)**
Liquidity constraints_Banks	-0.036 (0.055)
Liquidity constraints_Supply Chain	0.058 (0.065)
Price Based competition	0.09 (0.055)
Training	**0.366** (0.165)**
Size	**0.276***(0.072)**

Notes: The estimations include sector dummies. Marginal effects are presented
***, **, * denote significance on p<1%, 5%, 10%. Standard errors are reported in parentheses.

Dependent Variable Product Innovation	Model 4
Industry-University R&D collaboration*Education	0.033 (0.067)
Industry-University R&D collaboration*(1-Education)	**0.14** (0.064)**
Crisis deepening dummy	**-0.451*** (0.122)**
Exporting	0.282 (0.172)
Age	0.04 (0.108)
Low cost strategy	0.018 (0.14)
Differentiation Strategy	**0.502*** (0.139)**
Liquidity constraints_Banks	-0.033 (0.054)
Liquidity constraints_Supply Chain	0.06 (0.064)
Price Based competition	0.08 (0.054)
Training	**0.378** (0.162)**
Size	**0.244*** (0.071)**

Notes: The estimations include sector dummies. Marginal effects are presented ***, **, * denote significance on p<1%, 5%, 10%. Standard errors are reported in parentheses

Dependent Variable Product Innovation	Model 5
Industry-University R&D collaboration*young	0.03 (0.077)
Industry-University R&D collaboration*(1-young)	**0.126** (0.062)**
Crisis deepening dummy	**-0.447*** (0.122)**
Exporting	0.275 (0.172)
Education	-0.139 (0.322)
Low cost strategy	0.042 (0.14)
Differentiation Strategy	**0.502*** (0.139)**
Liquidity constraints_Banks	-0.034 (0.054)
Liquidity constraints_Supply Chain	0.065 (0.065)
Price Based competition	**0.09*(0.055)**
Training	**0.363**(0.164)**
Size	**0.275***(0.072)**

Notes: The estimations include sector dummies. Marginal effects are presented
***, **, * denote significance on p<1%, 5%, 10%. Standard errors are reported in parentheses

Model 2: Discussion of results

- Industry – University R&D collaborations drive innovation of firms as the crisis deepens, …and not just after the crisis outbreak.
- This result may imply that crisis facilitates the transition of the business productive system from a corporate model of knowledge production to a new distributed, inter-organisational, innovation model where joint networks and collaborations between universities and firms can more effectively

  - combine resources,
  - exploit increasing knowledge returns,
  - reduce cost of failure of R&D projects
  - and create value.
- Or simply it could be the effect of resources' constraints that most firms faced as the crisis was deepening.

Models 3, 4, 5: Discussion of results

- Non-exporting firms would benefit the most in the likelihood to innovate from the development of synergies in R&D projects with universities.
- Firms with employees of lower educational level, benefit more in terms of innovation when knowledge flows take place through the use of collaborations with universities, compared to firms with a high knowledge stock (proxied by the higher educational level of their employees.
- Young firms are more likely to benefit from collaborations with universities compared to older ones.
- Knowledge flows act as a key replenishment mechanism allowing for higher impact on the innovation output- when the knowledge stocks are low

Conclusions

- The crisis deepening reduces the probability of firms to be engaged in innovative activities.
- Knowledge flows via the channel of firm-university R&D collaborations drive effectively the innovation output process but this relation is not linear.
- Beneficial effects of industry-university collaborations in terms of innovation are more pronounced in the midst of the crisis rather than in the beginning of the crisis.
- Firms with lower levels of knowledge stocks benefit more in terms of innovation from knowledge flows with universities.
- training programmes, differentiation strategies and size improve innovative chances.

Thank you

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