Lifting the veil on patents and inventions

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The value of patent data
Collaboration Networks, Structural Holes, and Innovation: A Longitudinal Study

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To assess the effects of a firm’s network of relations on innovation, this paper elaborates a theoretical framework that relates three aspects of a firm’s ego network—direct ties, indirect ties, and structural holes (disconnections between a firm’s partners)—to the firm’s subsequent innovation output. It posits that direct and indirect ties both have a positive impact on innovation but that the impact of indirect ties is moderated by the number of a firm’s direct ties. Structural holes are proposed to have both positive and negative influences on subsequent innovation. Results from a longitudinal study of firms in the international chemicals industry indicate support for the predictions on direct and indirect ties, but in the interfirm collaboration network, increasing structural holes has a negative effect on innovation. Among the implications for interorganizational network theory is that the optimal structure of interfirm networks depends on the objectives of the network members.

The value of patent data
But...

“Not all inventions are patentable. Not all inventions are patented and the inventions that are patented differ greatly in their ‘quality’, in the magnitude of inventive output associated with them.”

Griliches (1990, p. 1169)
“A patent is a legal right to exclude. In an industry where the pace of technology is rapid and firms advance quickly upon innovations made by others, firms may patent for strategic reasons [...] to recoup investments in R&D. [...] But the importance of patent rights and their use may vary among firms even within one industry over time.”

Hall & Ziedonis (2001, p. 125)
So what?

• Take two firms, with firm A and B being the same size
  • Firm A: 50 patent applications, 45 patents granted
  • Firm B: 100 patent applications, 60 patents granted
• Which one is better at innovation?
• What if I told you they had both made 100 invention disclosures inside of the firm?
• No inference possible!

• Similar issue: inventive teams
  – You cannot observe those teams that worked on inventions which were not patented
Denrell (2003)
What happens inside organizations?

**WHAT WE OBSERVE**

- Invention disclosures
- Patent Applications
- Patents Granted

**WHAT WE DO NOT OBSERVE**

“Many of these **unpatented ideas probably did not exceed the threshold of novelty** necessary to obtain a patent. However, firms are also known to protect **important inventions by using trade secrets** and copyright. This feature of the data should suggest caution in the interpretation of the results. However, unless there is a systematic bias, the results should be **unaffected.”** Audia & Goncalo (2007. p. 13)
We have the data to test this assumption

• Data on invention disclosures (~35K) made by all employees of a large multinational company operating in a complex-product industry

• Each invention disclosure is evaluated and assigned to one of these categories
  1. Not novel ~ 50%
  2. Novel but not useful to the firm (at present) ~ 10%
  3. Novel and useful and it is patented ~ 30%
  4. Novel and useful and it is kept secret ~ 1%
We replicate two papers

- Singh & Fleming (2010)
  - They assess the impact of collaboration on the \textit{variance} of the quality of innovative outcomes (proxied by patent citations) in a wide range of industries

- Audia & Goncalo (2007)
  - They assess the impact of inventors’ past success on their future \textit{creativity} (proxied by number of granted patents) in the hard disk drive industry

Our strategy

- First we estimate their models using our patented inventions then we test for the presence of selection bias
How do we test if there is a selection bias?

Heckman two step procedure

1. Estimate the probability that an invention has been protected with a granted patent
2. Estimate the model explaining the main outcome variable using only the subset of granted patents controlling for the inverse Mill’s ratio
3. Check whether inverse Mill’s ratio is significant

Use data on inventions – are they put forward for patenting?
Instrumenting the decision to file a patent

• The Heckman procedure requires an instrument
  – a variable which affect the decision to patent but does not influence the main outcome variable

• Invention disclosures submitted towards the end of the financial year are less likely to be patented
  – **regardless of their quality** - because the budget set aside for patent filings is running low

• Instrument: Timing of evaluation by the firm
Sources of selection bias

Inventions that are novel but not useful to the firm (at present) ~ 10% of disclosures:

<table>
<thead>
<tr>
<th>Category</th>
<th>%</th>
<th>% patented</th>
</tr>
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<tbody>
<tr>
<td>Provisional patent applications</td>
<td>10.1</td>
<td>94.5</td>
</tr>
<tr>
<td>Inventions with narrow scope of application</td>
<td>55.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Inventions for which patenting does not offer useful protection</td>
<td>7.8</td>
<td>0</td>
</tr>
<tr>
<td>‘Shelved’ inventions – novel but not yet useful</td>
<td>26.3</td>
<td>2.9</td>
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</table>
## Replicating Singh & Fleming

<table>
<thead>
<tr>
<th></th>
<th>Singh &amp; Fleming estimates</th>
<th>Our estimates</th>
<th>Our estimates controlling for selection bias</th>
<th>Our estimates using invention disclosures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High quality</td>
<td>Low quality</td>
<td>High quality</td>
<td>Low quality</td>
</tr>
<tr>
<td><strong>Team</strong></td>
<td>0.347**</td>
<td>-0.125**</td>
<td>0.411**</td>
<td>-0.697**</td>
</tr>
<tr>
<td><strong>Effect size</strong></td>
<td>28%</td>
<td>-9%</td>
<td>5.8%</td>
<td>-4.5%</td>
</tr>
<tr>
<td><strong>Inverse Mill’s ratio</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sample</strong></td>
<td>509,840</td>
<td>509,840</td>
<td>~5,000</td>
<td>~5,000</td>
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Replicating Audia & Goncalo

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<th>Our estimates controlling for selection bias</th>
<th>Our estimates using invention disclosures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventor success</td>
<td>0.139*</td>
<td>0.120**</td>
<td>0.109**</td>
<td>0.033**</td>
</tr>
<tr>
<td>Effect size</td>
<td>31%</td>
<td>27%</td>
<td>24%</td>
<td>7.5%</td>
</tr>
<tr>
<td>Inverse Mill’s ratio</td>
<td></td>
<td>-0.237**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Events</td>
<td>1,665</td>
<td>~5,000</td>
<td>~5,000</td>
<td>~35,000</td>
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</table>
Replicating Audia & Goncalo

<table>
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<tr>
<th>Poisson Models: number of patents/inventions with new technology classes</th>
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<tbody>
<tr>
<td>Inventor success</td>
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<tr>
<td>----------------------</td>
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<tr>
<td></td>
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<tr>
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Key findings and limitations

• We find evidence of selection bias when patents are used to proxy individual creativity but not when patents are used to identify technology breakthroughs.

• Effect size of main explanatory variables are significantly different (by factor of 3-6) when we eliminate the source of the bias all together.

• Caveat: results might be driven by the low number of secret inventions and relatively low number of novel but not useful inventions.
Conclusions

• Be careful in drawing managerial and policy conclusions when using patent data to compare innovative performance across firms

• Consider other outputs of innovation process – e.g. publications

• Complement patent data with primary data on inventors’ activities (e.g. PATVAL survey)

• Studies on creativity could exploit data from contexts where the entire range of innovative efforts is observed (e.g. Open source projects, suggestion boxes, idea submissions sites)