Venture Capital Financing and Green Patenting

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Background, Motivation and Research question

Background

- The **European Green Deal** aims to make Europe the world’s first climate-neutral continent, in part by developing cleaner sources of energy and **green technologies**
- **Venture Capital** is a financing instrument which typically target truly **innovative firms**, help them grow and potentially make their technologies a new market standard

Motivation

- Investigate whether **Venture Capital** can be a **tool to spread green innovation** in Europe

Research questions

- Does **green innovation** and patenting increase the probability of **raising Venture Capital** financing?
- Is **green innovation an opportunity for VC**?
VC financing and the link with innovation is well documented (Florida & Kenney, 1988; Kortum & Lerner, 2001; Lerner, 2002; Da Rin & Penas, 2007; Arvanitis & Stucki, 2014; Hirukawa & Ueda, 2011; Faria & Barbosa, 2014; Bernstein et al., 2016, Akcigit et al. 2019)

It is widely held that, while imperfections in capital markets discourage investments in R&D, their high risk-return profile is typically very attractive to VC finance.

- In this context, patents can mitigate financing constraints by acting as a signaling device to investors (VCs) particularly in the case of start-up (Conti et al., 2013).
Challenges to the traditional VC business model for green ventures/innovations:

(i) high capital intensity of green ventures and the fact that take longer to reach the maturity phase (Criscuolo & Menon, 2015)
(ii) technical and managerial complexity (Amore and Bennedsen, 2016)
(iii) corporate governance issues (Amore & Bennedsen, 2016).
(iv) higher risk of market exit due to the infant stage of the sector

These features may reduce their attractiveness for VC finance compared to other high-tech ventures (Ghosh and Nanda, 2015)

At the same time:

long-term stable, predictable and credible environmental policies may:
- reduce the uncertainty and risk associated to investment in green,
- determinate (increase) the amount of equity finance invested in green ventures (Johnstone et al., 2010, Criscuolo & Menon, 2015)
## The data

### Adopted dataset

<table>
<thead>
<tr>
<th>Source</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>VentureSource (Dow Jones)</td>
<td></td>
</tr>
<tr>
<td>Orbis (Bureau van Dijk)</td>
<td></td>
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<tr>
<td>Patstat (patent statistical database created by the European Patent Office)</td>
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</tbody>
</table>

### Identifier
- ID is the **equity financing** deal

### Country
- **EU 27 + UK**

### Timespan
- **2008-2017**

### Available information
- **Financial data** from balance sheets on equity-backed firms (e.g. TA, R&D, debt)
- **Information** on the **equity transaction** (e.g. amount, date, round)
- **Green and non-green** technologies and patents associated to firms
Green patents are becoming more important for equity-backed firms

**Green Patents:**
- Based on the **methodology developed by the JRC** to derive indicators of global innovative activity in clean energy technologies
- **Green technologies** are identified through the Y02 and Y04 schemes of the Cooperative Patent Classification (CPC), that includes 9 subcategories of Climate Change Mitigation Technologies (CCMTs)
- The JRC methodology uses **patent families as a proxy for inventions**

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![Graph showing evolution of green and non-green patents of VC/PE-backed companies in our sample](chart.png)

1. Comparing the average number of patents between the periods 2000-2009 and 2010-2016, based on our matched DB.
2. Fiorini et al. (2017), Pasimeni et al. (2019), Pasimeni et al. (forthcoming)
3. (i) Technologies for adaptation to climate change; (ii) CCMTs related to buildings; (iii) Carbon capture storage (CCS), sequestration or disposal of greenhouse gases; (iv) CCMTs related to information and communication technology; (v) Reduction of greenhouse gas emissions, related to energy generation, transmission or distribution; (vi) CCMTs in the production or processing of goods; (vii) CCMTs related to transportation; (viii) CCMTs related to wastewater treatment or waste management; (ix) Systems integrating technologies related to power network operation, communication or information technologies
4. Patent families include all documents relevant to a distinct invention, including patent applications to multiple jurisdictions as well as those following regional, national and intern'l routes
Equity financing and Green Patents

- Approximately 17% of the sample is composed of firms having registered at least one patent.

- Non-green patents are more frequent than green patents. 18% of the total patents are green.

Note: application of patent completed before the VC/PE transaction based on our matched DB
# Sample firms’ characteristics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total</th>
<th>VC-backed firms</th>
<th>Other equity-backed firms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Green patents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of equity-backed firms with green patents (%)</td>
<td>0.032</td>
<td>0.034</td>
<td>0.030</td>
</tr>
<tr>
<td><strong>Other patents</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of equity-backed firms with other patents (%)</td>
<td>0.140</td>
<td>0.169</td>
<td>0.117</td>
</tr>
<tr>
<td><strong>Assets</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Assets (M€)</td>
<td>35.918</td>
<td>5.961</td>
<td>58.798</td>
</tr>
<tr>
<td><strong>Age</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years from the incorporation date</td>
<td>9.039</td>
<td>3.852</td>
<td>12.593</td>
</tr>
<tr>
<td><strong>Leverage</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Debt / Total Assets (%)</td>
<td>0.525</td>
<td>0.400</td>
<td>0.620</td>
</tr>
<tr>
<td><strong>R&amp;D</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency of equity-backed firms with &gt;0 R&amp;D expenditure (%)</td>
<td>0.020</td>
<td>0.019</td>
<td>0.021</td>
</tr>
</tbody>
</table>

* These variables are taken with a one-year lag
The model

- We estimate a **Probit Model** to investigate whether the presence of a non-green and / or a green patent is associated with a higher probability of raising a Venture Capital investment

\[
Pr(VC_{it}) = \beta_0 + \beta_1 GreenPatents_{it} + \beta_2 OtherPatents_{it} + \beta_3 X_{it-1} + \phi_t + \phi_s + \phi_c + \phi_{s,c} + \epsilon_{it}
\]

- **Pr(VC):** dummy variable which is equal to 1 if the firm raises a VC, while it is zero if it raises another equity-based financing in the analysed year;
- **GreenPatents:** dummy variable which is equal to 1 if the firm has a green patent before raising the equity financing, 0 otherwise;
- **OtherPatents:** dummy variable which is equal to 1 if the firm has a non-green patent before raising the equity financing, 0 otherwise;
- **X:** set of firms’ controls including the lagged relevant indicators (e.g., Assets, Age, R&D, Leverage)
- **Fixed effects** at the year, sector, country, and sector-by-country levels included in different specifications
Propensity Score Matching

- VC-backed firms might be systematically different from other equity-backed firms according to some unobserved characteristics.

- To reduce any potential sample selection bias, some specifications are conducted on a matched sub-sample built using the Propensity Score Matching approach to build statistically comparable groups in terms of VC-backed and other equity-backed firms.

- In PSM, control groups are identified by modeling the probability of a firm being VC-backed based on observed characteristics unaffected by the fact to be VC-backed or not.

- Specifically, the PSM uses firm’s industrial (country and sector) and financial (assets, age, leverage ratio, investments in R&D related to the year before the investment) characteristics.

- The matching between observations is based on the Nearest-Neighbor (NN) algorithm. Then, we impose the common support option, that requires that VC-backed firms have comparable other equity-backed firms with similar propensity scores.
Main findings

Baseline

- The probability of raising a Venture Capital investment increases for firms with a patent:
  - Green Patents: 6-19%*
  - Other Patents: 11-14%*
- The marginal effects are larger for green patents when including controls

Matched sample

- Results based on the matched sample confirm the first findings and further limit the range of marginal effects:
  - Green Patents: 10-20%*
  - Other Patents: 9-14%*
- All the marginal effects are larger for green patents

* Depending on the specification of the model. The range decreases when the full set of control variables are included in the estimation.
Robustness tests

**Alternative independent variable**
- We replicate the baseline model using the **ratio (%) between the number of green patents over the total number of patents** as main regressor.
- The **probability of raising a VC is higher when the share of green patents is larger** in the firm’s patents portfolio

**Restricted sample**
- We replicate the analysis **restricting the sample** to those firms owning either **mostly green patents (>50%)** or **having green patents only (100%)**, thus excluding mixed cases.
- These results are consistent with the main findings

**Sector analysis**
- We tag as «**green macro-sectors**» and «**green micro-sectors**» those NACE 2 **broad1 and 4-digit sectors**, respectively, with at least one green patent
- The **probability of raising a VC is not higher** for firms belonging to **green macro-sectors** than non-green macro-sectors, thus suggesting that the born-to-be-green characteristics of firms are **patent-specific** and not sector-specific

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Heterogeneous results

- We compare the probability of raising an **Independent VC** (IVC) vs a **Corporate VC** (CVC) or a **Business Angel** (BA) investment in the presence of (green) patents
- **IVCs are more prone** in investing in firms **with other patents** vs CVC and BA, while **no significant differences** emerge when looking at **green** patents

**CVC and BA**

**VC rounds**

- We compare the probability of raising a **Later- vs Early-stage VC** in the presence of (green) patents
- We do not find **any significant difference** across rounds
Thank you for your attention