



Venture Capital Financing and Green Patenting

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*Virtual Conference CONCORDì 2021
Session B II, Tuesday 23rd November*

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**?

Literature (1/2)

Literature

- 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).

Literature (2/2)

Literature

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:

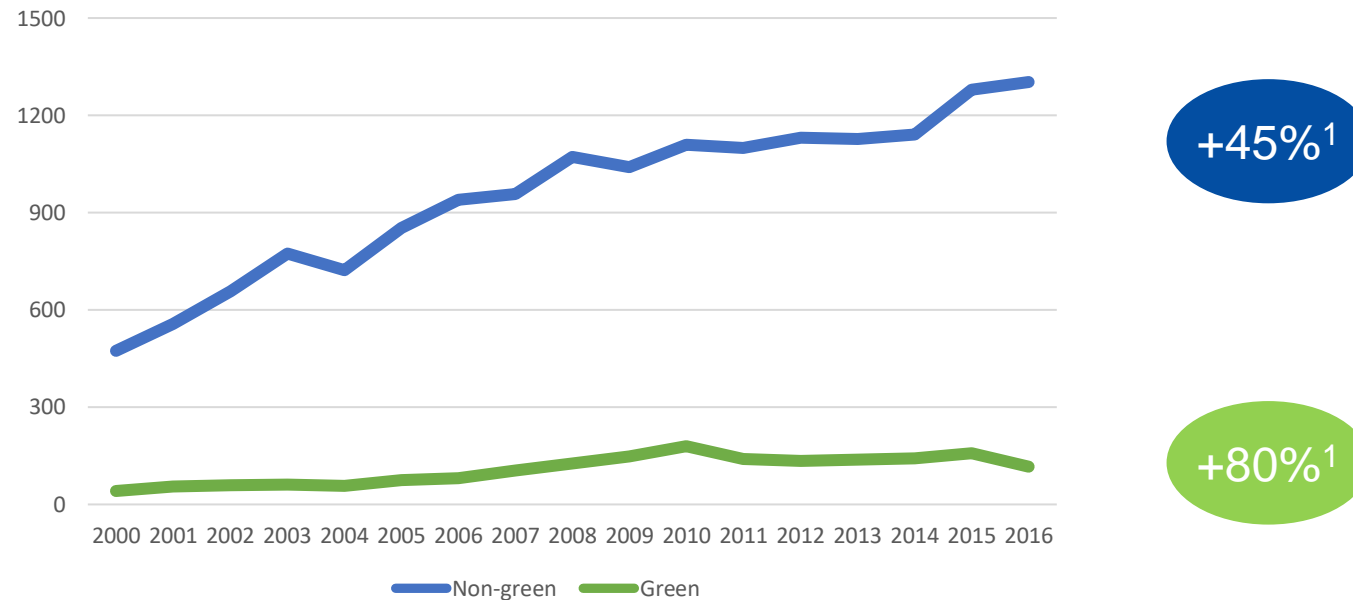
- reduce the uncertainty and risk associated to investment in green,
- determinate (increase) the amount of equity finance invested in green ventures (Johnstone et al., 2010, Criscuolo & Menon, 2015)

The data

Adopted dataset	Sources	<ul style="list-style-type: none">▪ VentureSource (Dow Jones)▪ Orbis (Bureau van Dijk)▪ Patstat (patent statistical database created by the European Patent Office)
	Identifier	<ul style="list-style-type: none">▪ ID is the equity financing deal
	Country	<ul style="list-style-type: none">▪ EU 27 + UK
	Timespan	<ul style="list-style-type: none">▪ 2008-2017
	Available information	<ul style="list-style-type: none">▪ 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

Evolution of green and non-green patents of VC/PE-backed companies in our sample



Green Patents:

- Based on the **methodology developed by the JRC** to derive indicators of global innovative activity in clean energy technologies²
- **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)³
- The JRC methodology uses **patent families as a proxy for inventions**⁴

1. Comparing the average number of patents between the periods 2000-2009 and 2010-2016, based on our matched DB.

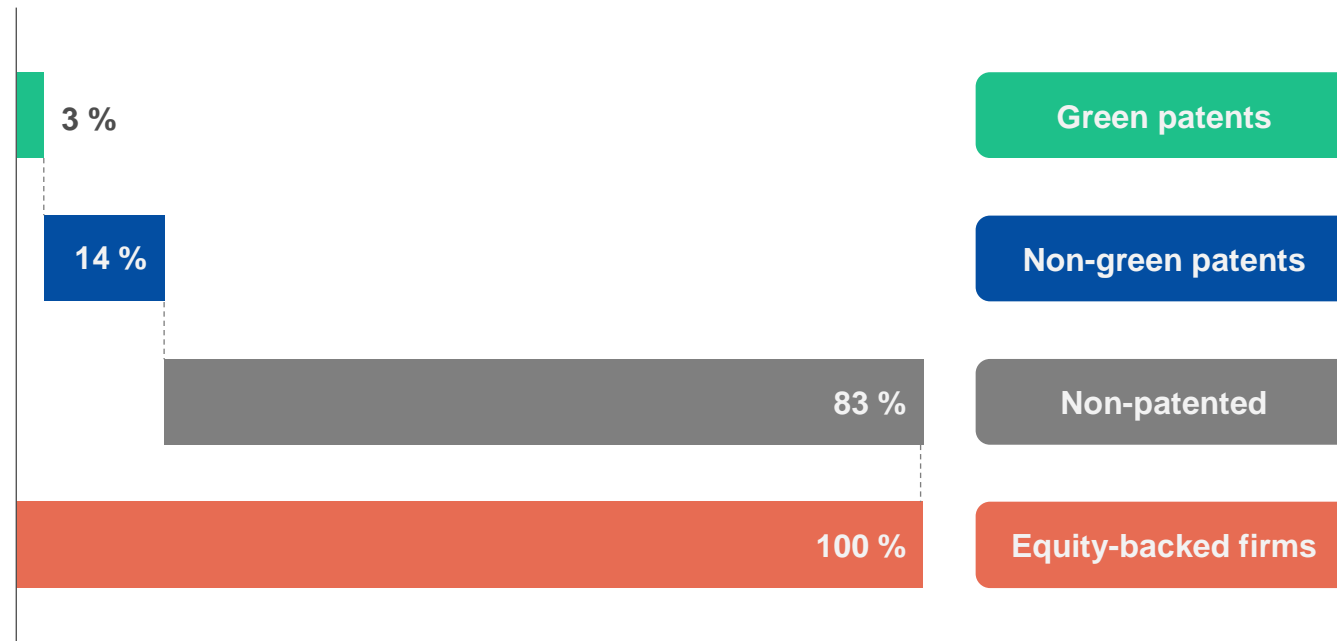
2. Fiorini et al. (2017), Pasimeni et al. (2019), Pasimeni et al. (forthcoming)

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

Application for patents before raising equity (VC/PE) financing



Note: application of patent completed before the VC/PE transaction based on our matched DB

- 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.

Sample firms' characteristics

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

* 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

$$Pr(VC_{it}) = \beta_0 + \beta_1 GreenPatents_{it} + \beta_2 OtherPatent_{it} + \beta_3 X_{i,t-1} + \phi_t + \phi_s + \phi_c + \phi_{s,c} + \epsilon_{it}$$

- **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 pat. 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

Heterogeneous results

CVC and BA

- 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

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