Access to Finance for Innovators in the UK's Environmental Sector

Abstract: Technological improvements are seen as one of the best solution in countering the environmental impacts of economic activity. Yet, the success of firms, especially SMEs, in the environmental sector is dependent on the presence of appropriate external financing to support their innovative activity. In an attempt to understand the circumstances surrounding the financing of 330 UK SME firms from the environmental sector between 2007-2010, we investigate the relationship between different types of innovation activity and sources of external finance. We observe a clear division of labour between the three external sources of finance, namely, banks, VC and government and identify that finance gap affects environmental SMEs with early stage and less applied research projects. We discuss the challenges for UK environmental SME to engage in innovative activity and call for an increased government support in order to support innovative SMEs with early stage projects and to instil confidence in the private investors by signalling long term commitment.

Keywords: Clean-technology, environmental sector, finance, venture capital, SME.
JEL: C21, G20, L53, O32, O33, Q55

1. Introduction

Access to external finance for small and medium sized enterprises (SMEs) has been the focus of an extensive literature that includes the case of innovative SMEs and the new technology based firms (NTBF). For SMEs with innovative activities, the combination of high levels of risk and uncertainty, information asymmetries and a lack of collateral often results in well-known market imperfections that lead to severe credit rationing for these firms, especially in the case of bank loans (Carpenter and Petersen, 2002a; Colombo and Grilli, 2007). Constraints to external finance can end up jeopardising innovative activity and consequently, the growth and development potential of innovative SMEs (Beck and Demirguc-Kunt, 2006; Carpenter and Petersen, 2002b, Canepa and Stoneman, 2008; Freel, 2000, Girma et al., 2008; Savignac, 2008). Venture capital (VC) finance can be seen as an alternative source of external finance that is better suited to the innovative nature of these firms, yet, it is not widely available in bank-based economic systems and the rejection rates are very high (Cosh et al., 2009). Moreover, VC finance is often motivated by short-term gains and therefore, focus only on firms with innovations that are close to the commercialisation stage (Mazzucato, 2011). Government grants are used in order to ease these market imperfections and support innovative SMEs, yet evidence suggests that in most cases these grants do not meet the needs of firms with the highest innovation and growth potential; and their effect on boosting innovation is limited unless they are well tailored to the needs of the targeted firms (Colombo et al., 2011; Hall, 2005; Mason and Brown, 2013; Schneider and Veugelers, 2010; Wallsten, 2000).

In this paper, we focus on 330 innovative SMEs in the UK's environmental sector in order to explore the relationship between innovation activities and sources of external finance. As argued in Carpenter and Petersen (2002a), availability of finance is most critical in key sectors that supply the significant knowledge for the future development of the economy. Environmental sector is one of those key sectors for the UK at a time the industry and innovation policies are dominated by a challenge to urgently and drastically reduce carbon emissions. An immediate boost of the innovations in the environmental sector is crucial for the UK to maintain its place in the 'green race' which continuously becomes more competitive due to increased global interest and competition in environmental

technologies (Fankhauser, 2013; GreenAlliance, 2013). Ensuring that the innovative SMEs in the environmental sector have access to the required external finance can be pivotal in determining the UK's success in achieving its environmental targets and taking a lead in the area of environmental innovations.

The main contribution of the paper is through investigating which sources of external finance are used to support the different types of innovation activities undertaken by the UK SMEs in the environmental sector. The literature on financial constraints for innovative firms generally tackles innovation under the broad 'R&D' label without unpacking the different innovation activities: namely basic, applied and developmental research, compiled under this label. Through disaggregating the broad definition of innovation into these more refined and meaningful parts, we are able to scrutinise the relationship between different sources of external finance and these different types of innovation activities. This exercise does not only provide a more detailed map of innovation activities and finance, but also allows us to examine the areas of innovation where financing constraints are more pronounced.

Our results reveal a clear division of labour amongst the financiers of the environmental sector innovations, where commercial banks stay away from the small and medium sized innovators all together and the UK government provides some funding, often in small amounts, for applied research projects. VC finance is limited to a rather small share of SMEs and favours those with the later stage developmental innovation projects with short-term returns. These results indicate that the finance gap in the environmental sector hits SMEs that focus on early stage innovation projects most severely. The implications of this for the UK's future are discussed in the paper along with policy recommendations to address this market imperfection.

The paper consists of 5 sections. The next section discusses the literature and sets out the hypotheses while Section 3 discusses the data and the empirical strategy used in the paper. In section 4 we discuss the empirical results and conclude in Section 5.

2. Review of the Literature

The industrial economics and innovation literatures on the environmental sector are fairly nascent with little and scattered evidence. As the growing emphasis on global warming is rather recent, so is the academic interest in the environmental sector, its innovations and the availability of finance in this sector. Even though financial constraints are long known to be a significant barrier to innovation (Canepa and Stoneman, 2008), to our knowledge, no academic study offers a thorough examination of the relationship between availability of finance and innovations in the environmental sector. Moreover, the lack of consensus on what constitutes the boundaries of the environmental sector poses significant challenges in the way of sector-specific empirical studies. Additionally, the SME section of the environmental sector has received even less attention in the literature due to data limitations on the activities of these firms.

In light of these multiple gaps in the literature, this study focuses on the innovative SME section of the UK's environmental sector and examines the relationship between different types of innovation activities and different sources of external finance. In doing so, we aim to bring insights from the innovation and financial constraints literatures and throw light on the current state of the innovation-finance relationship in the UK's environmental sector. This section discusses the literature on financial constraints that affect innovative SMEs and sets out the hypotheses tested in the empirical part of the paper.

2.1. Financial Constraints for Innovative SMEs

The issue of 'access to finance' has been at the cross-section of the finance and innovation literatures due to the crucial role external finance plays in facilitating the innovations of firms with limited internal resources. The most commonly used framework to discuss firms' demand for and use of external finance is the Pecking Order Theory which proposes that firms have a ranked preference over the source of financing used; preferring to use internal sources first, then, if necessary seek debt finance and finally equity based finance as a last resort (Donaldson, 1962; Myers, 1984). In this setting, it is well understood that costs of external finance are significantly higher than internal sources; and different sources of finance pose different costs.

Indeed, a broad body of literature gives support to the pecking order theory and confirms that majority of SMEs solely rely on their internal resources (Colombo and Grilli, 2007; Minola et al., 2013; Revest and Sapio, 2012). However, in the case of innovative SMEs, internal resources may not always suffice to finance and commercialise the innovation projects and firms end up having to look for external finance. Yet, these firms are hit by significant market imperfections when applying for external finance due to three well-known reasons (Carpenter and Petersen, 2002; Freel, 2007; Hall, 2005): Firstly, innovation projects are often lengthy, risky and the returns are uncertain with a highly skewed distribution. Secondly, information asymmetries characterise innovation projects, as the investor is often unable to fully evaluate the merit and potential of the project. Finally, small innovative firms make majority of their investments in intangible knowledge-based assets and therefore, lack the tangible collateral that can be secured against debt to signal lower risk to investors.

A great majority of the empirical SME literature confirms that these outlined disadvantages innovative SMEs face are very severe when applying to bank loans. Using a sample of 386 new technology based start-ups in Italy, Colombo and Grilli (2007) point to the detachment between innovation activities and bank loans as only 8% of the firms rely on bank loans at the time of starting up while more than 80% use their internal resources. These findings are in line with the results in Giudici and Paleari (2000) who show that high technology Italian SMEs face significant discrimination in their bank loan applications. Likewise, for the UK, using different datasets Canepa and Stomenan (2008), Freel (2000; 2007), Mina et al. (2013) and Cosh et al. (2009) find that higher levels of R&D and recent innovations reduce the likelihood of gaining access to bank loans. A review that highlights similar findings of the literature for the US and EU firms can be found in Revest and Sapio (2012). This literature alludes to the fact that more innovative firms are less likely to get financial support from banks.

While the relationship between availability of bank loans and innovation has not been tested in the context of the UK's environmental sector, a report prepared by Eventure Media (2009) finds that environmental SMEs in the UK are facing hardship in qualifying for bank loans due to their risky

innovation profiles[1]. In this paper, we further investigate the relationship between innovations and access to bank loans by focusing on different types and stages of firms' innovation activities (basic research, applied research and development, patenting, R&D collaborations) to find out which innovation activities, if any, are more or less likely to attract bank loans in the environmental industry. Our general expectation is that firms with innovative activities are less likely to receive bank loans.

Hypothesis 1: Firms with innovative activities are less likely to receive bank loans.

Despite the significant discrimination innovative SMEs face, bank loans still remain the most frequently used external source to finance innovation activities of these firms, especially in countries where venture capital markets are not well developed (Cosh et al., 2009). Venture capital (VC) is often cited as an appropriate form of external capital to support innovative SMEs because specialised and knowledgeable VC investors are able to overcome information asymmetries affecting SMEs and therefore, VC can help to mitigate the negative implications of credit rationing (Hall, 2002; 2005). The expectation is that venture capital can help fill the financing gap by providing significant amounts of risk capital to small and young innovative firms, for which bank loans, personal and informal sources of finance are not available or large enough to finance innovation (Kortum and Lerner, 2000). In addition, innovative firms need active management support and advice, particularly for technical start-ups where the entrepreneur is a technical specialist without commercial experience. One advantage of venture capital is the expected 'added-value' that the investor brings in the form of strategic advice and management support in terms of capabilities and network of contacts that can be utilised to help develop the firm (Hellmann and Puri, 2000; Hsu, 2004; Zook, 2004).

Yet, the effectiveness of VC in supporting innovative firms comes under question in most countries where VC markets lack the depth, experience and sophistication. Dosi's (1990) doubts on how well

[1] The following two excerpts have been noted by survey participants: *"We find it is very difficult to obtain loans from banks as we are doing research therefore we have no "track record" to satisfy banks demand"… "We have presented our business to two banking institutions - the lending committees in both cases have wanted tangible guarantees from the directors in place to cover the 30% they would be exposed to before offering funds. In one case a Senior Business Manager made the presentation on our behalf and was disappointed at his employers' attitude. The government must investigate the lending institutions and question their reluctance to back SMEs in the green energy sector"*(Eventure Media, 2009, p.26-27).

the VC is able to address the needs of innovative UK SMEs may still be viewed as relevant today: "*The 'market-based' British case, while revealing all the dangers of short-sightedness that such an arrangement entails, has not developed to any satisfactory degree mechanisms of allocation to innovative search, neither - until recently - to new ventures […]*" (p. 314). For instance Cosh et al. (2009), North et al. (2013) and Revest and Sapio (2012), amongst others, comment that VC finance is hardly accessible to UK technology based small firms. Mason and Harrison (2004) argue that majority of young ventures in the UK are not investment-ready, meaning that the entrepreneur and the management team lack credibility, the business plan is not well prepared and/or the product/service is not original enough. Moreover, the UK's VC markets, where VC and entrepreneurial firms meet, are characterised as 'thin markets' with significant difficulty for both parties in finding and contacting each other (Nightingale et al., 2009).

Furthermore, recent evidence suggests that VC fails to fill the finance gap for firms that undertake more risky and radical innovations. Later-stage innovations close to the point of commercialisation are more likely to be funded by VC than early-stage risky innovation projects. Mazzucato (2011) claims that VC only enters significantly big deals after the firm or the government absorbs the major risks of the innovation project. Gompers and Lerner (2001) and Mason and Harrison (2003) state that venture capital investments in the UK have focused on later stage investment opportunities and failed to develop a core of early stage venture capital skills. Pierrakis and Mason (2008) report that although the UK's private equity investment is the largest in Europe, investment for early stage opportunities is volatile and is only provided in small sums. Indeed, the 2013 British Venture Capital Association annual survey confirms that only 2% of members' investment activity was allocated toward early stage funding (including seed, start-up and early stage funding).

In the case of the environmental sector, while no previous study offers statistical evidence on the availability and use of VC. The closest approximation comes from the BVCA survey in 2012 that reports a total £365m of UK based venture capital investment, of which £166m was focused on

technology and £67m on clean technologies[2]. While a slightly older report reveals that a significant 20% of new technology based firms operating in the UK's clean technology field have access to VC (Eventure Media, 2009), Parris and Demirel (2010) show that VC is more likely to support a relatively small deals in later-stage incremental clean technology innovations rather than early stage radical clean technology innovations. In line with these findings, we expect to find that VC finance is associated with late stage innovations of SMEs in the environmental sector.

Hypothesis 2: Late-stage innovation activities of SMEs in the UK's environmental sector are more likely to be funded by VC.

Since VC funding can aid a very small proportion of innovative SMEs, and access to bank loans is limited, governments across the world have been keen to provide direct finance to SMEs in high technology sectors with the hope of boosting innovation and growth of those firms that are below the radar for traditional bank or VC finance (Hyytinen and Toivanen, 2005). The UK government has implemented a range of different financial policies with this effect, to provide SMEs and start-ups with direct seed funding (Mason and Harrison, 2004; Mason and Pierrakis, 2011; BIS, 2013). Cosh and Hughes (2010) report that innovative UK firms are much more likely to receive government funds compared to their US counterparts, yet the size of the grants are significantly smaller in the UK compared to the US. Mason and Pierrakis (2011) show that the government has continuously increased their share as an investor in the high technology ventures after the post-2000 technology crash that led the VC to become more cautious in investments. Mason and Pierrakis (2011) and Nightingale et al. (2009) also point to the rising trend of public-private co-investment model in the UK.

These findings are echoed in the context of the UK's environmental sector. To complement private investment, the UK government has extended grants to environmental companies to help bridge the need for investment. Eventure Media (2009) reports that a large 49.6% of technology based SMEs in

[2] Figures of £73m and £69m for VC investment in cleantech in 2011 and 2010 respectively.

the environmental sector had received government support or grants. However, they argue the awareness of available support is still low at the firms' end and majority of the grants received were below 10,000 GBP.

In the paper, we investigate the type(s) of innovation activities that make SMEs most attractive when applying for government's innovation finance. Direct government funding to promote innovation in SMEs is often intended to facilitate the practical applications of ideas that emerge from basic research (Martin and Scott, 2000). Therefore, it is expected that government's innovation finance would be related to applied R&D activities of firms. Therefore, we expect to find a close association between applied research activities and government funding. More recently, a top priority in the distribution of government funds in the UK, as well as in many other countries, has been to support the involvement of SMEs in innovative industry-university and SME-large firm knowledge transfer collaborations (Czarnitzki et al., 2007; Hewitt-Dundas, 2012; Kang and Park, 2012). We expect the collaborative activities of SMEs to also increase their ability to attract government funding.

Hypothesis 3: SMEs involved in applied research and collaborations are more likely to receive government funding.

3. Data and Empirical Approach

The empirical sections of this paper serve two objectives. Firstly, through a thorough discussion of the descriptive statistics, we hope to provide evidence on the innovation and finance related characteristics of the SME firms in the UK's environmental sector. This is an important contribution as no previous academic study that focuses on these specific firm group can be found despite the growing interest and emphasis on environmental matters in the UK and Europe. Secondly, we systematically test the three hypotheses outlined in Section 2 of the paper in order to shed light on the relationship between different sources of finance and different types of innovation.

3.1. Data

The paper uses a recently developed dataset of 330 SMEs with less than 250 employees from the UK's environmental sector, collected via a structured survey. The survey was conducted between

October 2010 and February 2011 on a total number of 2100 firms that were identified to be innovative SMEs in the environmental sector. A clear problem faced in the construction of the sampling frame for the survey was the absence of consensus on the definition of the environmental sector. Due to the nascence of the literature in this area, no clear official definition or any industry-based background study could be found as a reference point for our work. Therefore, we proceeded by conducting a thorough search of online and print publications that cover the environmental industry firms as well as electronic lists collated by various trade organisations within the environmental industry. We included all 2100 active innovative firms mentioned on these publications[3]. While this approach does not rely on a more standard framing methodology (e.g. SIC classification), in absence of such a clear classification, it was deemed to be the most feasible avenue for our empirical strategy. While potential sample selection concerns can be validly raised in relation to our empirical investigations, we tried to mitigate these by asking firms for detailed information on how they describe their activities and cleaned the database by discarding firms that maintain activities unrelated to the environmental sector. We hope that this study can serve as an initial investigation of the environmental sector SMEs in the UK and future work can refine and improve the definition of the environmental sector as this industry matures and evolves.

The questionnaire design was tested using a small pilot study and the necessary adjustments to the questionnaire were undertaken based on the feedback from these firms. The first wave of the survey was conducted online in October 2011 and firms were sent two additional reminders within a 6 week period. The non-responding firms were, then, contacted via postal mail two times until February 2011. We had 330 responding firms corresponding to a 19% response rate after taking into account the surveys that were returned in the mail[4]. Responding firms were distributed across all regions of the UK, providing a good coverage of UK wide activity.

[3] The publications we consulted are those provided by RenewableUK (http://www.renewableuk.com), Cleantech Group Database (http://www.cleantech.com), The Greenbag UK Cleantech Start-up Index (2008), Guardian Top 100 Cleantech Firms List for 2008/2009, Times Best Green Companies List (2009), Independent: A Guide to the World's Greenest Companies, Envirotech Directory (http://www.envirotech.uk.com) and Eco-firms Directory (http://www.ecofirms.org/directory.php).

[4] 16 firms whose business activities did not relate to the environmental sector were discarded from the dataset.

The survey focused on the external finance obtained by the firms, innovative and R&D activities, as well as additional (self-declared) characteristics of the firm and its operation. The FAME database of financial information on UK firms published by Bureau van Dijk was used to provide additional information on the financial statements of responding firms, as well as for undertaking basic checks on respondent information and yielded additional data on firm sales, profits and registration dates.

3.2. Industry Analysis and Descriptive Statistics

The literature's empirical findings on the UK's Environmental Sector are highly limited. Therefore, this section aims to provide preliminary insights into the innovation and finance relationship for SMEs in this sector. Environmental sector SMEs carry increased significance due to the recent rise in the number of small and new technology based firms operating in the UK's clean-technology field, spanning a range of environmental technologies from alternative energy and materials to energy saving smart electronic household products. These firms are delivering quick and efficient low-energy solutions to the economy (Cullen, 2009; Lee *et al*., 2009). Moreover, they conduct a significant amount of the sector's R&D in part due to increasing outsourcing of R&D to environmental SMEs operating at the cross-boundaries with the equipment supply industry (Jacquier-Roux and Bourgeois, 2002).

In the survey, firms were asked a number of questions that mainly aimed to identify their characteristics, innovative activities, funding resources (if any) as well as their performance. The percentage of firms according to self-declared company characteristics and activities are identified in Table 1. Accordingly, 33% of companies reported to be R&D companies. We also note 34% of companies provided consultancy and advisory services, either as a solo activity or jointly with other activities such as manufacturing. The majority of companies sold directly to business, and given the low level of export activity (19% of firms), the UK was the major market focus. In terms of technology applications, 48% of companies reported they were involved in "clean-tech" applications and 54% in environmental applications.

<TABLE 1 AROUND HERE>

A closer look at the firms' perception of R&D activities in Figure 1 reveals that R&D is highly valued amongst firms as the importance of basic research, applied research and development activities are all rated around 4 out of 5 on average (5 being the highest score). A major difference exists between those firms that consider themselves as specialised R&D firms and those that do not. We find that R&D firms value basic and applied R&D as well as development activities to be more important for their success compared to firms that are not specialised R&D firms. Similarly, purchasing or providing R&D services as well as collaborating with public or private organisations scored higher on R&D firms' priorities.

<FIGURE 1 AROUND HERE>

We also asked firms to rate their entrepreneurial motivations on an increasing scale of 1 to 10 according to the statement, *"Entrepreneurial firms are more competitive, growth minded and innovative than other companies".* The distribution of these scores is displayed in Figure 2 and reveal that majority of firms in our sample consider themselves highly entrepreneurial.

<FIGURE 2 AROUND HERE>

In relation to finance, Table 2 reports that 49% of firms surveyed have used commercial finance such as bank loans, credit cards and/or equity finance to support their business. 24% of firms used informal sources of capital, which include funding sourced from personal accounts, friends and family or company staff. Approximately 21% of companies obtained funding from public sources such as the UK Government and European Union. Venture capital (VC) funding was secured by 16% of firms despite the increased VC interest in the clean-technology sector internationally.

The most frequently used source of funding by firms in the last three years has been traditional debt finance, used by 30% of companies. This finding is in line with various UK based SME studies on access to finance in other sectors (BIS, 2012; Cosh et al., 2009; Warwick, 2009). A question on firms' future expectations for external finance reveals an increased future demand overall, including government funding despite the planned public sector cuts (See Table 2).

<TABLE 2 AROUND HERE>

3.3. Methodology

In the paper, we analyse the factors that affect firms' ability to receive different sources of external finance; namely VC, bank loans and government funds. In particular, we use probit models to identify the relationship between firm characteristics, firms' different innovation activities and the source of finance they used.

In the probit model, the dependent variable y_i represents a binary outcome (0/1) for the type of finance obtained. In this case, different probit models are run for equations using different measures of finance received, including VC, bank loans and government funds[5]:

$$y_i^* = \beta' X_i + \varepsilon_i,\ \ \varepsilon \sim N(0, \sigma^2) \qquad \text{(Equation 1)}$$

$$y_i = \begin{cases} 0\ if\ y_i^* \leq 0 \\ 1\ f\ y_i^* > 0 \end{cases}$$

The set of independent variables X_i ,reported in Table 3 include various variables that define the business characteristics, including whether the business is a family business, the entrepreneurial motivations of the company, whether it exports and its age as well as a set of descriptors of its R&D and innovation activity. In particular to the innovation variables, we include proxies for the different stages of firms' R&D activities, namely, basic, applied and developmental R&D. We also control for whether the firm has ever obtained any patents, whether they provide or purchase R&D services and whether they take part in R&D collaborations.

[5] This approach assumes that the errors from each estimated probit model are distributed independently and identically with a univariate normal distribution. This assumption of independence of errors terms means that information about a firm's access to a particular type of finance is not related to that firm's probability of obtaining a different type of finance. To check this strong assumption we also ran a multivariate probit model to measure the correlation coefficients between models (cross equation) using different financing outcomes, regressed on the same set of independent variables. A likelihood ratio test for a simultaneous null of zero correlation across equations was not rejected. Similarly correlation coefficients for paired equations were also not statistically significant. Given these results, using multivariate probit would yield inefficient estimates, and the probit results preferred. It is worth noting that the estimates obtained in the univariate and multivariate probit models were very similar.

<TABLE 3 AROUND HERE>

Recent studies have revealed that it is important to control for firms' demand for finance when exploring the determinants of access to finance, since many firms do not apply for external finance at all (Cosh et al., 2009; Han et al., 2009; Kon and Storey, 2003 amongst others). In our regressions, we control for firms' tendency to seek external finance with a proxy variable constructed by using four finance related questions in the survey. Three of these questions asked firms to rate the importance of (1) access to venture capital and equity-based investment; (2) access to credit and loans and (3) access to government funds, for the performance of the firm. The final question asked firms to rate how important the cost of obtaining external finance is. The proxy for financial demand is determined as a dummy variable equal to 1 if the Likert scale produced from the average of these four individual Likert measures for the indicated variables is greater than or equal to four, zero otherwise (each Likert item is measured on scale from 1 – not important to 5 – critically important). To be considered as seeking finance; the firm must, on average, respond to these four measures with at least a score 4- 'very important'[6]. Table 4 shows the variables used to construct the 'financial demand' proxy. An initial look at this proxy variable, as reported in Table 5, indicates that firms with higher financial are more likely to receive venture capital, bank loans and UK funding, reflecting the greater willingness to seek out and apply for funding.

<TABLES 4 and 5 AROUND HERE>

4. Results

In order to test the hypotheses set out in Section 2, we use the Probit model in Eqn. 1 and investigate the associations between firms' different innovation activities and the different external sources of finance they received. The estimation results are reported in Table 6 for each different source of external finance.

[6] Alternative calculations for this financial demand proxy were also considered, such as using the first principle component, provide very similar results but have more abstract interpretation.

<TABLE 6 AROUND HERE>

We first start by discussing the case of the most commonly used source of external finance by the SMEs in the environmental sector: the bank loans. Our results are in agreement with the common finding in the literature that larger firms (i.e. with higher levels of sales in Table 6) are more likely to receive bank loans. The results related to the innovation variables reveal that bank loans, at best, do not impact the firms' ability to receive finance. In the case of firms with developmental R&D activities and interests, there is even a lower likelihood of receiving bank loans. It is also worth noting the negative, yet insignificant, signs on most of the innovation variables, including applied research, patents and firms' collaborations with other companies and universities. These findings are broadly in agreement with the literature, which confirms that innovation activities are not particularly attractive to banks; and may even deter bank lending and offer support to the statement in H1.

The next source of finance we explore is the Venture Capital (VC) finance. As discussed in Section 2, VC is commonly described as the most appropriate source of finance for innovative companies despite rising concerns that VC is only supportive of a small subset of innovative activities, namely late stage and low risk innovations that are closer to commercial markets. Our results confirm these concerns by showing that it is only the latest stage of R&D (i.e. developmental R&D) that makes firms more likely to receive VC funds. Earlier and potentially more risky stages of R&D (i.e. applied and basic) that are further from the point of commercialisation are not associated with VC funding. We also note the positive significant impact of the patents the firm holds upon the ability to receive VC funds. This goes to confirm that patents act as a signal to VC funders and reduce the uncertainties and risks associated with identifying truly innovative firms. These findings confirm that only later-stage, lower risk innovations are able to attract VC finance, confirming Hypothesis 2.

Finally, we consider which types of innovation activities increase the likelihood of environmental sector SMEs to receive UK government grants. The results indicate that patents are a significant attraction for government grants. We interpret this as a confirmation that patents act as a signal to the governments in the selection of the most promising innovators and similar findings can be found in Wallsten (2000). Amongst the different stages of R&D activities, government funds appear to focus

on the middle stage, applied R&D activities while there is also evidence (at 10% significance level) that firms that collaborate with universities are more likely to receive innovation funding from government sources; a manifestation of the UK Government's ongoing encouragement for university-company collaborations through provision of financial support. These findings extend support to H3.

These results point to a division of labour amongst the funders operating in the UK's environmental sector: The banks largely stay away from the innovative SMEs; whilst Venture Capital funds finance a limited portion of innovation activities that are late-stage. Government funds aim to fill the gap by financing the middle stage innovation activities covered by applied R&D. More risky and less applied (i.e. more basic) innovation projects of SMEs in the environmental sector, however, struggle to receive any external finance and may well have to rely on firms' internal resources in the form of owner/staff finance and retained profits. While a division of labour amongst funders is clearly natural and even necessary; it is concerning that firms with less applied and early stage innovation ideas are not able to receive external finance. The lack of external finance for firms engaging in basic R&D, is an issue common to SMEs in many sectors, but remains a critical problem if environmental SMEs are to achieve a strong contribution to the wider environmental innovation system of the UK .

5. Discussion and conclusions

The aim of this paper has been to investigate which different financing channels currently support the different innovative activities of small and medium sized enterprises in the UK's environmental sector. There is a clear need to develop a robust innovation system that can deliver solutions to the pressing national and international environmental challenges and to develop the environmental innovative capabilities to maintain leadership in the 'green race' (Fankhauser et al., 2013). Setting up the appropriate system of financing for innovative SMEs is a vital part of this challenge.

In this paper, we find that bank loans, the most commonly available form of external finance, are not supportive of SMEs' innovation activities in the environmental sector. Indeed, we have some

evidence that innovative activities reduce firms' ability to receive funding from banks. This result echoes the findings of the access to external finance literature in relation to innovative SMEs, reconfirming that banks are not particularly supportive of innovators. The results also indicate that Venture Capital fills the finance gap for innovators only to a small extent, as only later stage innovations of environmental SMEs associated with developmental R&D are able to receive VC funds. Mazzucato (2011) argues that "*Venture Capital is not so risk loving*" (p.39) and either comes in the form of very small early stage seed funding or arrives at the latest stage with the objective of earning high returns following the sale or IPO of the company. Our findings are in line with this view that VC only plays a very narrow role in supporting innovations in the UK's environmental sector and we reconfirm the low-risk preferences of the UK's clean technology venture capital investors as found in Parris and Demirel (2010).

The government funds provided to SMEs in the environmental sector are found to favour those with applied innovations. In this respect, the government appears to be more risk loving than venture capitalists, as it is willing to concentrate on comparatively early stage innovations. However, there is a finance gap related to the earliest stages of research that are more 'basic' and 'less applied' in nature and inherently involve higher risks. No source of external finance is willing to support SMEs with these less applied and riskier innovation ventures. While internal resources and retained profits are a way of financing basic research activities, it is clear that a very high majority of SMEs lack the necessary internal resources to do so. While this is not an uncommon problem, it highlights a major barrier in the way of UK's ambitions to become a world leader for environmental innovations and clean technologies. Investments into basic R&D are necessary to maintain absorptive capabilities in the knowledge underlying the more applied research. Its absence will lead to a shortage of fruitful ideas that can be turned into commercial success through applied and developmental research. We would recommend the government finance to also extend support to the earlier and more basic stages of R&D activities in order to address this finance gap. A greater government commitment towards environmental innovations would not only assist SMEs with early stage innovations but also instil confidence in banks and VC to invest in to innovative environmental SMEs.

Acknowledgements: This study has been partially funded by the British Academy Small Research Grant (2008-912: HGDE A3973) and European Community's Seventh Framework Programme (FP7/2007-2013) under Socio-economic Sciences and Humanities, grant agreement n° 217466.

REFERENCES

Beck, T., Demirguc-Kunt, A., 2006. Small and medium-size enterprises: Access to finance as a growth constraint. Journal of Banking & Finance 30, 2931–2943.

BIS (2012) SME access to external finance, BIS Economics Paper No.16, Department for Business Innovation & Skills, (London: HMSO).

Canepa, A., Stoneman, P., 2008. Financial constraints to innovation in the UK: evidence from CIS2 and CIS3. Oxford Economic Papers 60, 711–730.

Carpenter, R.E., Petersen, B.C., 2002a. Capital market imperfections, high-tech investment, and new equity financing. The Economic Journal 112, F54–F72.

Carpenter, R.E., Petersen, B.C., 2002b. Is the growth of small firms constrained by internal finance? Review of Economics and statistics 84, 298–309.

Colombo, M.G., Grilli, L., 2007. Funding gaps? Access to bank loans by high-tech start-ups. Small Business Economics 29, 25–46.

Colombo, M.G., Grilli, L., Murtinu, S., 2011. R&D subsidies and the performance of high-tech start-ups. Economics Letters 112, 97–99.

Cosh, A., Cumming, D., Hughes, A., 2009. Outside Enterpreneurial Capital. The Economic Journal 119, 1494–1533.

Cosh, A., Hughes, A., 2010. Never mind the quality feel the width: University–industry links and government financial support for innovation in small high-technology businesses in the UK and the USA. The Journal of Technology Transfer 35, 66–91.

Cowling, M., Liu, W., Ledger, A., 2012. Small business financing in the UK before and during the current financial crisis. International Small Business Journal 30, 778–800.

Czarnitzki, D., Ebersberger, B., Fier, A., 2007. The relationship between R&D collaboration, subsidies and R&D performance: empirical evidence from Finland and Germany. Journal of applied econometrics 22, 1347–1366.

Cullen, S.E. 2009. Alternative energy powers up. Thomson-Reuters. http://science.thomsonreuters.com/news/2009-10/8552060/

Donaldson, G., 1962. New framework for corporate debt policy. Harvard Business Review 40, 117–131.

Dosi, G., 1990. Finance, innovation and industrial change. Journal of Economic Behavior & Organization 13, 299–319.

Eventure Media (2009) *The development of clean technologies in the UK*, Rushlight Events, Available at: http://www.rushlightevents.com/images/File/RUSHLIGHT%20CLEANTECH%20SURVEY%20REPORT.pdf.

Fankhauser, S., Bowen, A., Calel, R., Dechezleprêtre, A., Grover, D., Rydge, J., Sato, M., 2013. Who will win the green race? In search of environmental competitiveness and innovation. Global environmental change 23, 902–913.

Freel, M.S., 2000. Barriers to product innovation in small manufacturing firms. International Small Business Journal 18, 60–80.

Freel, M.S., 2007. Are small innovators credit rationed? Small Business Economics 28, 23–35.

Girma, S., Gong, Y., Görg, H., 2008. Foreign direct investment, access to finance, and innovation activity in Chinese enterprises. The World Bank Economic Review 22, 367–382.

Giudici, G., Paleari, S., 2000. The provision of finance to innovation: a survey conducted among Italian technology-based small firms. Small Business Economics 14, 37–53.

Gompers, P.A., 1996. Grandstanding in the venture capital industry. Journal of Financial economics 42, 133–156.

Green Alliance, 2013. The global green race: a business review of UK competitiveness in low carbon markets, available at: http://www.green-alliance.org.uk/uploadedFiles/Publications/reports/The%20global%20green%20race.pdf

Hall, B.H., 2002. The financing of research and development. Oxford review of economic policy 18, 35–51.

Hall, B.H., 2005. The financing of innovation. The Handbook of Technology and Innovation Management 409–430.

Hewitt-Dundas, N., 2012. Research intensity and knowledge transfer activity in UK universities. Research Policy 41, 262–275.

Hyytinen, A., Toivanen, O., 2005. Do financial constraints hold back innovation and growth?: Evidence on the role of public policy. Research Policy 34, 1385–1403.

Jacquier-Roux, V., Bourgeois, B., 2002. New networks of technological creation in energy industries: reassessment of the roles of equipment suppliers and operators. Technology analysis & strategic management 14, 399–417.

Kang, K.-N., Park, H., 2012. Influence of government R&D support and inter-firm collaborations on innovation in Korean biotechnology SMEs. Technovation 32, 68–78.

Kon, Y., Storey, D.J., 2003a. A theory of discouraged borrowers. Small Business Economics 21, 37–49.

Kortum, S., Lerner, J., 2000. Assessing the contribution of venture capital to innovation. RAND Journal of Economics 674–692.

Lee, B., I. Iliev, and F. Preston. 2009. Who owns our carbon future? Chatham House.

http://www.chathamhouse.org.uk/publications/papers/view/-/id/775/

Mason, C., Harrison, R., 2003. Closing the regional equity gap? A critique of the Department of Trade and Industry's regional venture capital funds initiative. Regional studies 37, 855–868.

Mason, C., Brown, R., 2013. Creating good public policy to support high-growth firms. Small Business Economics 40, 211–225.

Mason, C., Pierrakis, Y., 2013. Venture capital, the regions and public policy: the United Kingdom since the post-2000 technology crash. Regional Studies 47, 1156–1171.

Mazzucato, M., 2013. The Entrepreneurial State: Debunking public vs. private sector myths. Anthem Press.

Mina, A., Lahr, H., Hughes, A., 2013. The demand and supply of external finance for innovative firms. Industrial and Corporate Change 22, 869–901.

Minola, T., Cassia, L., Criaco, G., 2013. Financing patterns in new technology-based firms: an extension of the pecking order theory. International Journal of Entrepreneurship and Small Business 19, 212–233.

Muûls, M., 2008. Exporters and credit constraints: A firm-level approach. National Bank of Belgium.

Myers, S.C., 1984. The capital structure puzzle. The journal of finance 39, 574–592.

Nightingale, P., Murray, G. et al., 2009. From funding gaps to thin markets. NESTA Research Report, available at: http://www.nesta.org.uk/publications/funding-gaps-thin-markets

North, D., Baldock, R., Ullah, F., 2013. Funding the growth of UK technology-based small firms since the financial crash: are there breakages in the finance escalator? Venture Capital 15, 237–260.

Revest, V., Sapio, A., 2012. Financing technology-based small firms in Europe: what do we know? Small Business Economics 39, 179–205.

Savignac, F., 2008. Impact of financial constraints on innovation: What can be learned from a direct measure? Econ. Innov. New Techn. 17, 553–569.

Schneider, C., Veugelers, R., 2010. On young highly innovative companies: why they matter and how (not) to policy support them. Industrial and Corporate change 19, 969–1007.

Veugelers, R., 2011. Europe's clean technology investment challenge. Bruegel Policy Contribution.

Wallsten, S.J., 2000. The effects of government-industry R&D programs on private R&D: the case of the Small Business Innovation Research program. RAND Journal of Economics 31, 82–100.

Warwick (2009) *The effect of the credit crisis on UK SME finance*, [Online], (Warwick: Warwick Business School), Available at: http://www.esrc.ac.uk/_images/Evidence%20briefing%20-%20finance%20for%20SMEs_tcm8-13957.pdf

Zook, M.A., 2004. The knowledge brokers: venture capitalists, tacit knowledge and regional development. International Journal of Urban and Regional Research 28, 621–641.

FIGURES

Figure 1: Importance of R&D activities for SMEs in the Environmental Sector

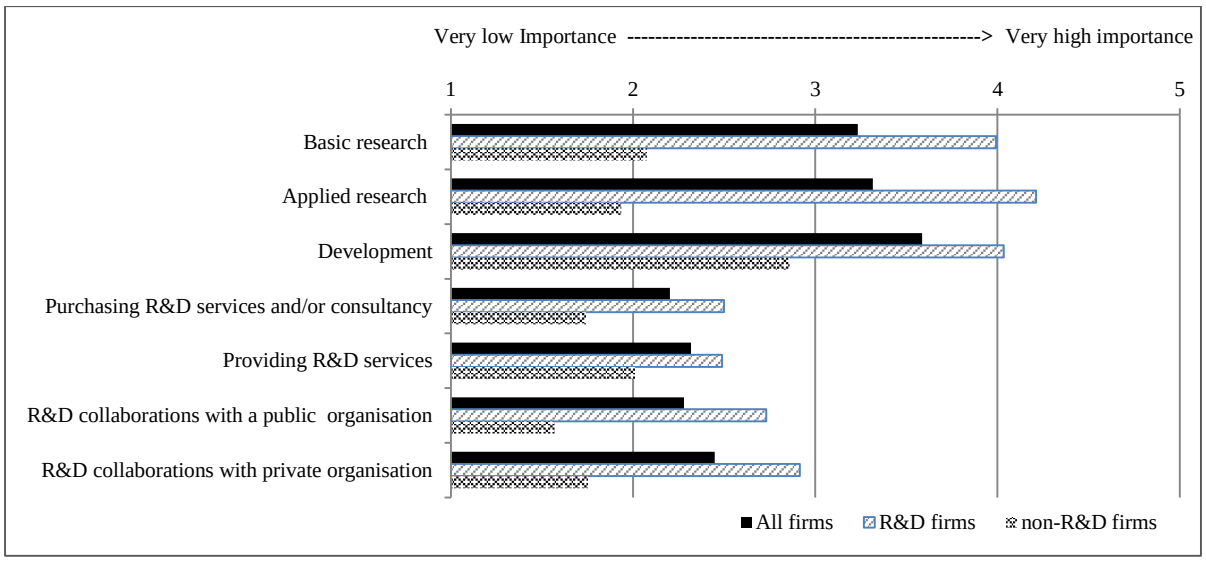
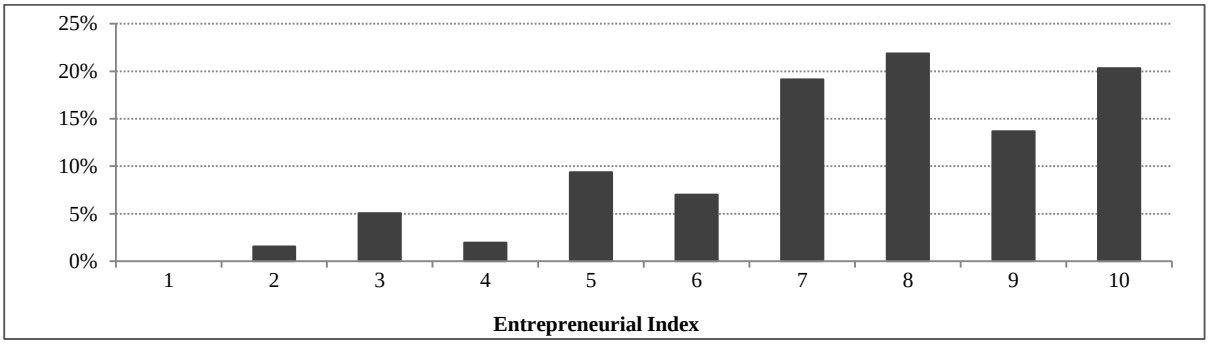


Figure 2: Entrepreneurial Characteristics of SME Firms in the Environmental Sector



TABLES

Table 1: Self-Declared Company Characteristics in the Sample

COMPANY CHARACTERISTICS			
Commercial For Profit	73%	Clean-technology Applications	48%
Entrepreneurial	36%	Environmental Applications	54%
Family Owned	17%	Green Business	45%
Non-Profit Organization	5%	Sustainability	54%
COMPANY ACTIVITIES			
Research and Development	33%	Selling to General Public	20%
Manufacturing	28%	Selling to Businesses	51%
Service Based	26%	Selling to Government Institutions	26%
Consultancy and Advisory	34%	Exporting	19%
		Importing	12%

Table 2: Sources of Finance Used and Expect to Use

Top 5 Sources of current sources of finance	Used in last 3 years (% firms)	Expect to use in next 3 years (% firms)
1. Bank Loans	30%	45%
2. Retained Profits	28%	46%
3. UK Government Funding	19%	30%
4. Venture Capital	16%	36%
5. Company Staff Funds	14%	21%

Table 3: Descriptive Statistics for Independent Variables

Variable Name	Data generation	Description of coding/variable	Mean	Std. Dev.	Min	Max
Entrepreneurship	”Entrepreneurial firms are more competitive, growth minded and innovative than other companies” Where would you put your firm on a scale of 1 to 10 (10 = highly entrepreneurial)	Dummy variable =1 if firm scores > 7; 0 otherwise.	0.61	0.49	0	1
Family Business	Is the company a family business? (Yes/No)	Dummy variable (yes = 1; 0 otherwise)	0.20	0.40	0	1
R&D Company	Is the company a specialised R&D business? (Yes/No)	Dummy variable (yes = 1; 0 otherwise)	0.32	0.47	0	1
Manufacturing	Is manufacturing a activity conducted by the firm? (Yes/No)	Dummy variable (yes = 1; 0 otherwise)	0.28	0.45	0	1
Export	Is exporting an activity conducted by the firm ? (Yes/No)	Dummy variable (yes = 1; 0 otherwise)	0.20	0.40	0	1
Age	Firm age calculated from company registration date (years)	Log(firm age + 0.01)*	1.61	1.98	-4.60517	4.47745
Sales	State firm’s sales for the last full financial year (£)	Log (sales + 0.01)	12.34	5.62	-4.61	21.16
Patent	Has the firm previously applied for a patent, or used a patent to protect business interests?	Dummy variable (yes = 1; 0 otherwise)*				
Rate the importance of the following activities to your business during the last three years (scaled from 1 (very low) to 5 (very high):						
Basic R&D	Basic research (defined as the development of new knowledge)	Dummy variable =1 if firm scores > 4; 0 otherwise	0.21	0.41	0	1
Applied R&D	Applied research (advancing new productions o services which are new to the market)	Dummy variable =1 if firm scores > 4; 0 otherwise	0.29	0.45	0	1
Development R&D	Development (refinement of existing products or services including product and process design)	Dummy variable =1 if firm scores > 4; 0 otherwise	0.26	0.44	0	1
Purchase R&D	Purchasing research and development services and/or consultancy from other firms or research organisations	Dummy variable =1 if firm scores > 4; 0 otherwise	0.05	0.22	0	1
Provide R&D	Providing research and development services, know-how and/or consultancy to other firms, or research organisations	Dummy variable =1 if firm scores > 4; 0 otherwise	0.09	0.283	0	1
University Collaborations R&D	Collaborations with a university or public research organisation on a research and development based project(s).	Dummy variable =1 if firm scores > 4; 0 otherwise	0.086	0.274	0	1
Company Collaborations R&D	Collaborations with other firms on research and development based project(s).	Dummy variable =1 if firm scores > 4; 0 otherwise	0.09	0.284	0	1
Financial demand	Determined from multiple questions (below)	If average of ‘credit demand’, ‘equity demand’, ‘cost of finance’ and ‘government support’ >=4 , dummy variable = 1; zero otherwise)	0.38	.49	0	1

Notes: * As some firms were recent start-ups or reported zero sales and adjustment of 0.01 was made to all observations when taking logs.

\

Table 4: Measures used to construct financial demand proxy

Rate the importance of the following activities to your business performance during the last three years						
Score	1 Not important at all	2 Somewhat important	3 Important	4 Very important	5 Critically important	Mean score
Access to credit or loans	36%	18%	19%	16%	11%	2.50
Access to venture capital and equity based investment (e.g. angel finance)	44%	15%	14%	11%	16%	2.41
Government support	21%	17%	21%	22%	18%	2.98
The cost of obtaining external finance	33%	14%	16%	24%	12%	2.71

Table 5: Sources of Finance Used by financial demand measure

Top 5 Sources of current sources of finance	Financial demand low (% firms)	Financial demand high (% firms)
1. Bank Loans	22%	43%
2. Retained Profits	26%	14%
3. UK Government Funding	17%	23%
4. Venture Capital	11%	18%

Table 6: Regression Estimates

VARIABLES	**Dependent Variable: BANK LOANS**		**Dependent Variable: VENTURE CAPITAL**		**Dependent Variable: UK FUNDING**	
	Coefficient	**Robust Std.Error**	**Coefficient**	**Robust Std.Error**	**Coefficient**	**Robust Std.Error**
INNOVATION VARIABLES						
Patent	-0.087	0.073	0.182***	0.041	0.136**	0.057
Basic R&D	0.116	0.084	-0.006	0.051	-0.040	0.064
Applied R&D	-0.084	0.083	0.075	0.051	0.130*	0.068
Development R&D	-0.171**	0.079	0.090**	0.041	0.024	0.062
Purchase R&D	0.040	0.136	-0.090	0.090	-0.092	0.106
Provide R&D	0.007	0.108	-0.017	0.065	-0.046	0.089
R&D collaboration with university	-0.002	0.101	-0.064	0.062	0.149*	0.084
R&D collaboration with another firm	-0.025	0.118	-0.035	0.062	-0.020	0.085
FIRM CHARACTERISTICS						
log(Sales)	0.021***	0.007	0.007**	0.004	-0.005	0.004
Age	0.009	0.018	-0.019**	0.009	0.011	0.014
Exporter	-0.109	0.080	0.011	0.052	-0.052	0.065
Entrepreneurial	-0.085	0.059	0.063	0.049	0.042	0.057
Family business	-0.016	0.067	-0.148*	0.089	-0.021	0.066
Manufacturer	0.115	0.076	-0.010	0.050	-0.043	0.061
Finance demand	0.251***	0.053	0.094**	0.042	0.013	0.054
Chi2	43.26***		31.11***		53.64***	
Pseudo R2:	0.158		0.1251		0.310	

Note: Reported coefficients are marginal effects. Statistical significance, * at 10% levels; ** 5% levels; *** at1% levels. N = 233, as some firms did not disclose sales data this reduced the sample size for the regression analysis. Estimates without including sales as a variable produce similar results.