



Addressing barriers to eco-innovation: Exploring the finance mobilisation functions of institutional innovation intermediaries



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ABSTRACT

This research article explores the role of institutional innovation intermediaries in accelerating the commercialisation of (clean) technologies. Drawing on the finance and innovation intermediaries literatures, we show that financial barriers to eco-innovation can be partly overcome by particular functions of institutional innovation intermediaries; this in turn mobilises private finance along the innovation process. Therefore, we empirically evaluate the roles and instruments of institutional innovation intermediaries (innovation intermediation, policy support, public–private cooperation, financial instruments). Our contribution intersects both the finance and the innovation systems literature by exploring the finance mobilisation functions of institutional innovation intermediaries to address barriers to eco-innovation along the innovation process.

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1. Introduction

The ongoing debate about how to mitigate climate change has encouraged policymakers to initiate R&D for eco-innovations. The aim of these initiatives is twofold: firstly, to reduce carbon emissions and, secondly, to foster long-term economic green growth (Strand and Toman, 2010; OECD, 2009). However, complex system failures occur surrounding the commercialisation of eco-innovations¹ due to high uncertainty, the absence of carbon markets and the resulting technological lock-in (Leitner et al. 2010). Many firms and research institutes invent technologies that are eventually not introduced to the market because of underinvestment in R&D or other (finance-related) barriers such as imperfect capital markets, difficult scalability, asset intensity, the absence of complementary assets such as infrastructure and an inadequate regulatory environment (Marcus et al., 2013; Kenney and Hargadon, 2012; Olmos et al., 2012; Mathews et al., 2010; Haley and Schuler, 2011). The incorporation of the finance perspective at an early stage, including the cooperation of innovative firms and research institutes with

financiers, could leverage public and private funds more effectively, enhance innovation activity and finally accelerate the commercialisation and diffusion process. Consequently, especially for climate change-related eco-innovation, there is huge potential in connecting public support with private finance, because of the persistent information asymmetries between innovators and financiers (Mowery et al., 2010).

Key actors in the innovation process include institutional (i.e. government-affiliated) intermediaries that play a crucial role in establishing and governing a closer collaboration and in fostering knowledge flows between innovators and financiers to reduce information asymmetries and uncertainty (Kivimaa, 2014; Howells, 2006; Hoppe and Ozdenoren, 2005; Moore et al., 2012a). In recent years, a lot of work has been done on innovation intermediaries (Howells, 2006; Katzy et al., 2013; Klerkx et al., 2015; Klerkx and Leeuwis, 2009; van Lente et al., 2003; Yusuf, 2008), resulting in conceptual and qualitative evidence that innovation intermediaries at the intersection of public and private R&D and commercialisation have beneficial effects (Kivimaa, 2014; Klerkx and Leeuwis, 2009; Yusuf, 2008; van Lente et al., 2003). More specifically, previous research has looked at their functions (Hoppe and Ozdenoren, 2005; Howells, 2006), how innovation intermediaries enhance user–producer interactions and demand articulation (Boon et al., 2008, 2011), their role in commercialising research (Yusuf, 2008), their interaction with the policy environment (Klerkx and Leeuwis, 2009) and their broader role with regard to stimulating a transition towards sustainability (Kivimaa, 2014; Moore et al., 2012b; van Lente et al., 2003).

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¹ On the basis of previous literature (Horbach et al., 2012; Foxon and Pearson, 2008; Rennings, 2000), this article adopts the following definition of eco-innovations: the invention, commercialisation and diffusion of clean technologies that reduce carbon emissions and/or other environmentally negative impacts and thus contribute to sustainability.

Although it has been recognised that innovation intermediaries help in mobilising several resources for innovation, the previous literature on innovation intermediaries has not investigated the mobilisation of finance for innovation. If previously separated literature streams on financing innovation and innovation intermediaries are drawn together, it becomes apparent that innovation intermediaries could play an important role in addressing financial barriers to eco-innovation along the innovation cycle, as they hold a critical position between market actors and government (Howells, 2006; Kivimaa, 2014; Yusuf, 2008; Mowery et al., 2010). As there has been no systematic evaluation of institutional innovation intermediary roles and functions to address barriers to eco-innovation and correspondingly mobilise private finance, our paper seeks to address this gap by analysing the following research question: *How do institutional innovation intermediaries address the complex set of barriers surrounding (eco-)innovation especially from R&D to commercialisation, with an emphasis on mobilisation of finance?*

We address this question in the context of eco-innovation, as innovation system problems such as thin markets for finance, information asymmetries and failing markets for technologies are more pronounced there, but we also believe it to be of relevance for innovation in general. We present qualitative in-depth evidence, exploring institutional innovation intermediaries' finance mobilisation functions and roles. The article is structured as follows. Section 2 outlines the theoretical underpinnings and integrates the streams of literature on innovation finance and innovation intermediaries. Section 3 sketches the methodological approach taken to assess the role of intermediaries and to evaluate their finance mobilisation functions. Section 4 presents the findings, and Section 5 interrogates these findings with theory to draw conclusions and to derive policy implications in Section 6.

2. Theoretical background

2.1. Financing R&D and innovation

Scholars consider financiers as crucial to support the commercialisation and diffusion of new, clean and low-carbon technologies generated by eco-innovation processes (Hekkert and Negro, 2009; Hekkert et al., 2007; Perez, 2002; Schumpeter, 1939), and several researchers have highlighted an underinvestment in R&D as a market failure for innovation activity in the early stages (Hall and Lerner, 2010; Hall, 2002; Myers and Majluf, 1984): Firstly, financiers, from their market logic perspective, cannot evaluate the quality of new research because of its highly uncertain nature (Jaffe et al., 2005; Akerlof, 1970; Arrow, 1962). Possible gains from R&D cannot be fully appropriated by the firm because of knowledge spill-overs, i.e. the social returns are higher than the private return appropriated (Jaffe et al., 2005; Griliches, 1992). Secondly, imperfections in capital markets affect firms' fundraising capability (Hall, 2002). Financing innovation and its related market failure are clearly an issue within the framework of innovation systems, but the broad question of financing innovation activity has not been treated holistically, although several authors have indicated that the financial innovation system underlying national and technological innovation systems is a significant driver of innovation activity and should therefore include well-coordinated policies (Dahlstrand and Cetindamar, 2000; O'Sullivan, 2006; Perez, 2013; Wonglimpiyarat, 2011). Private finance is highlighted as a critical factor in particular in the context of a transition towards eco-innovation (Leete et al., 2013; Mathews et al., 2010; Moore et al., 2012a; Perez, 2013).

Within the innovation policy mix that is created to enable this transition, different policy instruments are implemented (see Borrás and Edquist, 2013 for a generic overview of innovation policy instruments), of which economic transfers comprising different forms of finance is one. Different phases of the innovation process, i.e. basic and applied R&D, demonstration and commercialisation, pre-commercial phases, niche-market and the supported commercial as well as the fully commercial phase call for different forms of finance, the so-called finance

chain of innovation (Auerswald and Branscomb, 2003). In the basic and applied R&D phases, governments use subsidies and grants to address underinvestment in R&D that is risky due to intangibility and the limited extent to which it can be appropriated in terms of tangible returns to the firm (Link and Scott, 2010; Dahlstrand and Cetindamar, 2000).

When the commercialisation phases (demonstration, pre-commercial, niche-market and supported commercial) are reached – when 'investment readiness' is proved by signalling the quality of the business proposition linked to the emerging technology – external financiers such as business angels and venture capitalists (VCs) start financing (Mason & Harrison 2001). Informed financiers (i.e. so-called competent VCs – Dahlstrand and Cetindamar, 2000) try to overcome underlying information asymmetries and other barriers, such as a lack of managerial talent, marketing capabilities or networks, thereby reducing the monitoring and moral hazard problems (Da Rin et al., 2006; Repullo and Suarez, 2000; Holmstrom and Tirole, 1997). However, VCs have several shortcomings, such as the need to have a well-functioning equity market and a focus upon only certain industries at a time, that make them unsuitable for investing in infrastructure, larger R&D projects or asset-heavy firms and projects (Hall and Lerner, 2010; Oakey, 2003; Hall, 2002; Kenney and Hargadon, 2012). In addition, private equity, mezzanine and bank finance are often not available because of lack of collateral or the overall level of risk relating to the technologies and the institutional environment (Ughetto, 2007, 2010). More mature firms often rely on internal funds; however, as commercial viability is often uncertain, these companies refrain from commercialisation activities. In many cases, this leaves structural holes (e.g. known as the 'valley of death') in the commercialisation phase, since private equity, many VCs and credit financiers are often unable to seamlessly invest either in companies that reach the end of the public R&D support phase or in complementary assets such as the infrastructure required for commercialisation (Auerswald and Branscomb, 2003). Consequently, this can lead to thin financial markets as difficulties arise in the supply of, and demand for, finance. Simply increasing demand or supply is not sufficient, as coordination problems often arise between innovators (e.g. entrepreneurs), financiers and government (Nightingale et al., 2009; Dahlstrand and Cetindamar, 2000). Policymakers could therefore systematically strengthen the market-demand side by establishing public procurement programmes or public-private research partnerships in order to strengthen the technological capability to support the supply side (Audretsch and Lehmann, 2004; Auerswald and Branscomb, 2003; Edquist and Zabala-Iturriagoitia, 2012; Hargadon, 2010; Link and Scott, 2010).

In later stages of the innovation cycle (supported commercial and fully commercial), (clean) technologies face regulatory risks, flawed market pricing mechanisms or policy coordination failures (Weber and Rohrer, 2012; Haley and Schuler, 2011; Foxon et al., 2005). In this situation, governments could provide incentives to the financial sector and play a catalytic role in providing risk capital. This could be done by regulating certain industries, setting up institutions to make investments more profitable (Borrás and Edquist, 2013; Wonglimpiyarat, 2011) or using direct instruments such as public procurement for innovation (Edler and Georgiou, 2007; Edquist and Zabala-Iturriagoitia, 2012; Guerzoni and Raiteri, 2015). An overview of instruments used to finance innovation is provided in Table 1.

2.2. The role of intermediaries in addressing financial barriers

One way to address the obstacles and structural financial barriers in the innovation cycle (see Table 1) is to have intermediaries between different actors (Howells, 2006). These actors intermediate knowledge, technologies and finance, which is crucial for advancing markets (Stewart and Hyysalo, 2008; Boon et al., 2008; Howells, 2006; Hoppe and Ozdenoren, 2005). Howells (2006, p.720) defines an innovation intermediary as 'an organisation or body that acts an agent or broker in

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