Journal of Evolutionary Economics (2020) 30:741–771
https://doi.org/10.1007/s00191-020-00660-0

REGULAR ARTICLE

Mapping variety of innovation strategies sponsored by the policy-mix: an analytical framework and an empirical exploration

Isabel Maria Bodas Freitas[1]

Published online: 28 January 2020

Abstract

Several studies claim that to address the current economic and social challenges that face societies requires a range of public instruments promoting a variety of new technologies, markets and institutions. However, these studies say little about how to monitor the degree to which the policy-mix fosters variety in the system. This paper attempts to contribute to on-going efforts in the innovation policy field by developing such an analytical framework. Taking a microeconomic approach, this framework proposes that the degree to which the policy mix promotes variety generation in the system can be understood by examining the innovation strategies of recipients of public innovation support. Specifically, the framework proposes to examine three different aspects of firms' strategies and characteristics, which the literature has shown as central to their innovation behavior and outcomes: a) the innovation search path; b) the forms of governance for technological sourcing; and c) the learning loci. We provide an example of how this framework can be fruitfully applied.

Keywords Policy-mix · Innovation policy · Innovation strategies · Variety generation

JEL classification O30 · O31 · O38

1 Introduction

The innovation policy-mix available to firms includes different types of instruments, designed and implemented by different policy authorities, involving different actors and addressing various innovative processes (Flanagan et al. 2011). However, diversity in policy design (in terms of number of instruments used and/or the different objectives

✉ Isabel Maria Bodas Freitas
Isabel-Maria.BODAS-FREITAS@grenoble-em.com

[1] Grenoble Ecole de Management, Université Grenoble Alpes ComUE, 12 rue Pierre Sémard-BP 127, 38001 cedex 01 Grenoble, France

targeted) does not guarantee per se that the policy-mix will create effective support for multiple learning and innovation activities. Given that policy instruments interact (Costantini et al. 2015; Costantini et al. 2017a) and that policy designers and policy implementers often are different organizations with different characteristics and agendas (Foray and Llerena 1996; Costantini and Crespi 2013), the effective innovation activities and technologies that are sponsored and fostered may not match the policy objectives. The literature points to the need for a model in which firms and policy-makers interact in real time through the exercise of their capabilities (Cashore and Vertinsky 2000; von Tunzelmann 2009). Understanding the strategies of the firms to which innovation activities have been publicly sponsored could help to address some of the concerns related to the effect of the policy on the generation of variety in the system as well as to the coordination of policy-making by different authorities. For instance: Does the policy-mix support firms and systems with diverse learning and innovation activities, or does it sponsor firms with a narrow set of activities and strategies? Are the policy-mixes designed and implemented at different levels of policy-making complementary or reinforcing, that is, do they sponsor effectively different or similar activities?

From an evolutionary perspective, economic growth and structural change depend heavily on the process of variety generation and renewal (Schumpeter 1942; Nelson and Winter 1982; Metcalfe et al. 2006). From this perspective, technology and innovation policy-making should be concerned not with correcting market incentives, but with designing institutional frameworks and policies that encourage the accumulation of capabilities by different and heterogeneous actors (e.g., policy-makers, intermediaries, firms with different market, technology and innovation capabilities and strategies) (Metcalfe 1994; Laranja et al. 2008). Within these frameworks, technology and innovation policies should be aimed at generating variety and competition in the development of technological solutions and business experiments (Metcalfe 1994, 1995). This is because the possibility to get efficient solutions to specific challenges improves by widening the search spectrum, multiplying commercial experiment of alternative solutions as well as by adapting existing solutions to different domains (Nelson and Winter 1982; Laursen 2012). Hence, several recent studies have called for public policies that allow societies, through trial and error, to create a plurality of non-zero sum technological, market and institutional responses that will enable them to address current social challenges (Mowery et al. 2010; Foray et al. 2012). In other words, public policy is called upon to foster the innovation activities of a diversity of firms and other national actors pursuing specific innovation activities through a plurality of strategies (Hoppmann et al. 2013). In particular, generation of variety of technologies and business experiments is seen as crucial to combat global warming, since it is important to overcome the short-term negative influence of policies targeting carbon emissions reduction on other societal challenges such as employment growth or poverty reduction (Hargadon 2010; Costantini and Crespi 2013; Costantini et al. 2015). While existing literature sheds light on the rationale for policy-making to target a variety of innovation activities, there have been few attempts to develop frameworks to examine and monitor the degree to which the policy-mix sponsors variety in the system.

Policy-makers can expect their policies to have different resonance in the economy, depending on the innovation strategies and activities undertaken by public support

recipients (Dosi et al. 2010; Bodas Freitas et al. 2017). To promote variety creation, public support needs to reach diverse actors that rely on different innovation sources, apply different learning processes and have different motivations to produce and diffuse knowledge (Teubal and Andersen 2000). Therefore, microeconomic information on the recipients of public support is needed to understand whether the policy-mix is supporting variety creation in the system (Metcalfe 1995). This information may also permit to respond to concerns over coordination of innovation policy across different levels of policy-making, to identify degrees of differentiation, specialization and inertia within the policy-mix and to guide policy adaptation and policy experimentation.

The present study argues that the extent to which the policy-mix fosters the generation of variety in the system can be understood by examining the strategies of public support recipients. It proposes to examine three aspects of firms' strategies central to their innovative behavior and outcomes: the innovation search path; the forms of governance for technological sourcing; and their learning loci. In other words, rather than focusing on the characteristics of policy instruments used, and their specific design and implementation, the framework developed in this study proposes to examine the extent to which the policy-mix fosters variety in the system by focusing the strategies and characteristics of the public sponsored firms. This framework can be used to examine variety in multi-level policy-mixes (i.e. where interaction occurs because the same policy instrument is covered by different levels of policy governance, over geographic or policy spaces) and in multi-instrument policy-mixes (i.e. where interaction occurs because different instruments target similar and/or different groups). In this paper, we provide one example of how this framework can be used to assess the degree of variety being promoted in the system and complementarity in the multi-level policy-mix. Specifically, we use data on firms that received public financial support for innovation by different levels of policy-making in France during the 2000s.

The paper is organized as follows. Section 2 reviews the different theoretical foundations for the policy rationale to sponsor and monitor variety generation in the system. Section 3 develops a three-dimensional framework based on firms' innovation activities and strategies. Section 4 discusses possible empirical applications of the framework, and presents the data used to empirical apply the framework. Section 5 presents and discusses the empirical evidence. Section 6 concludes the paper.

2 Mapping the extent to which the policy-mix fosters variety generation

Several studies highlight the advantages of policy-mixes that reach a variety of (heterogeneous) actors with different functions, using diverse types of resources, engaged in several specific activities and technologies and with specific spatial coverage (Mowery et al. 2010; Hoppmann et al. 2013). Therefore, we understand variety in policy-mix as the extent to which the policy-mix promotes variety generation in the system. Providing public support for a variety of innovation activities implemented by actors with different characteristics and strategies may accelerate and widen search activities as well as business experiments (with new technological solutions or repurposing existing solutions to different domains) (Nelson and Winter 1982; Metcalfe 1994; Laursen 2012). By inducing competition in the development and use

of multiple technologies, business models and institutions, generation of variety of solutions and experiments may accelerate and make more efficient the system's response to specific challenges, in particular avoiding lock-in in inferior technologies (Metcalfe 1995; Metcalfe et al. 2006). Therefore, policy focus on promoting variety generation is crucial to address societal challenges and to achieve objectives such as reducing global warming, which requires a range of actors to develop, improve, customize and adopt alternative energy technologies and to ensure that established actors are not the only ones to benefit from public programs (Hargadon 2010; Fredriksson et al. 2018; Kefferpütz 2018).

Contributions in the public policy literature highlight the fact that policy effectiveness seems dependent on the appropriateness of the characteristics of the policy network, (Bressers and O'Toole Jr 1998; Howlett 2009). This stream of the literature proposes that policy objectives related to specific informational and institutional environments need specific policy design and formats of implementation (Peters 2000; Blair 2002; Howlett 2019). For instance, Bressers and O'Toole Jr (1998) argue that if the objectives of the actors in the target group are similar, policies should provide additional resources; however, if their objectives are dissimilar, policies should rely upon regulation. Sabatier (1986) suggests that bottom-up policy approaches are more appropriate in situations where there is no dominant technology, but with a large number of actors with no power dependency and a primary interest in the dynamics of different local situations. In addition, the effectiveness of the policy-mix seems dependent on the degree of alignment in terms innovation objectives between policy designers and policy implementers, which are often different organizations with different characteristics and agendas (Foray and Llerena 1996). Thus, to address a variety of actors involved in different innovation activities, technologies and markets, policy-makers may need to design and implement multiple policy programs targeting different actors and to exploit several policy instruments (Teubal and Andersen 2000).

However, the literature on the policy-mix has stressed that interactions among different policy instruments may occur, resulting from having been designed and implemented at different policy governance levels or because different instruments are targeting the same population or the same learning processes (Flanagan et al. 2011). The use of a mix of policy instruments may introduce various difficulties, as actors will be exposed to contradicting incentives (Magro and Wilson 2013; Reichardt and Rogge 2016). Empirically, while neglecting that the design of policy instruments may differ across systems and countries, and firms' and systems' responses to policy instruments may be distinct, evidence suggests that leveraging on the complementarities among policy objectives and respective instruments may increase the efficiency of public policies. For example, in a study of OECD countries, Costantini et al. (2017b) show that comprehensive policy-mixes balanced in terms of demand-pull and technology push influence positively eco-innovation, but a mix with an excessive number of instruments is detrimental. Cantner et al. (2011) show that technology push and demand pull instruments combined increase inventive capacity related to wind and solar technologies in Germany, but also that the combination of demand pull and systemic instruments seems to be detrimental to increasing network size because it tends to favor existing actors rather than attracting new ones. In a study of Flemish firms, Veugelers (2012) finds that a combination of regulation and subsidies has a greater influence on eco-innovations than the application of either individually. Hence,

understanding variety, as the different types of innovation encouraged, this stream of the literature expects variety to be promoted through the design of policy-mixes making use of both technology-push and demand-pull instruments, which are particularly efficient to encourage respectively, the exploration of new technologies and the market exploitation of relative more mature technologies (Nemet 2009; Costantini et al. 2015).

Overall, these contributions advance our understanding of how the economic, technological and social-politic contexts of the policy need to be reflected in the design of the policy-mix, as well as how the effectiveness of the policy-mix can be leveraged by exploiting complementarity among the policy instruments used. However, as the intrinsic characteristics and strategies of public support recipients seem to determine how they respond to policy (Dosi et al. 2010), the effect of similar policies (and policy-mixes) may differ across systems and economies. In addition, these contributions are mostly silent on how policy-design, which aims to foster alternative growth paths, can achieve its objectives when being coherent with the established policy network. The innovation activities and strategies of the established public support recipients will shape how this public support itself is applied (Teubal and Andersen 2000; Dosi et al. 2010) and, consequently, the ability of policy-making to influence the ways that current socio-economic challenges are tackled.

On the one hand, the decision of established recipients on the new technologies and products to develop may reflect their existing assets and capabilities, and the possibility of a relative smooth market transaction without fully cannibalizing existing markets (Furr and Snow 2014). Hence, despite the fact that newly developed technologies may represent an advance in relation to their existing products and technologies, the innovations that they produce are far behind the ambitious policy objectives and what may be technologically possible (Fredriksson et al. 2018; Kefferpütz 2018). This occurs because the new technologies are developed to be used as 'single' complements to existing ones to improve marginally their efficiency rather than to be used in a system of new technologies and product designs that permit the replacement of existing, less efficient production systems. It also occurs because the newly developed technologies did not make use of advanced technological knowledge, hence their technological trajectories are considered less interesting than others for addressing the socio-economic challenge, and their developments deviate resources from more interesting, alternatives ones (Fredriksson et al. 2018; Costantini et al. 2015). On the other hand, policy-makers may also resist implementing some policies with the fear that the replacement of incumbents' technologies and products produces a great disruption in the national employment and growth (Neslen 2016; Jolly 2018; Kefferpütz 2018). This is, for example, the case in the European automobile industry, where major players have been slowing down the take-off of an alternative, less polluting transport system (Fredriksson et al. 2018; Kefferpütz 2018).

Indeed, this is the fundamental problem of public policy when trying to address current socio-economic challenges: established industrial players have strong interests in the continuous improvement of current technologies but not in disruptive technological alternatives. Therefore, to address major socio-economic challenges and at same time avoid premature lock in, it seems imperative that public policy focuses on promoting variety in the system by reaching a variety of actors with diverse capabilities and strategies, engaged in a number of different technologies (Metcalfe 1994, Metcalfe

1995). In this context, monitoring the degree to which policy-mixes foster diversity of innovation activities and strategies becomes even central.

Taking a microeconomic approach rather than a policy design approach, we propose to develop a framework to examine variety in the innovation activities and strategies sponsored under the policy-mix. A microeconomic approach, traditionally used to examine the association between firms' behavior and outcome, has also been used to assess efficiency of public policy, in particular, additionality of financial support for innovation (e.g. Czarnitzki et al. 2007; Bodas Freitas et al. 2017). Here, instead, we propose to use a microeconomic approach to characterize the policy-mix. In other words, rather than following the tradition of the public and innovation policy literatures to examine the characteristics of policy-mix by focusing on the policy design (characteristics of policy instruments and policy networks), we propose to examine the degree to which the policy-mix fosters variety by looking at the innovation strategies of firms that received public financial support for innovation.

Figure 1 plots the review of the different streams of the literature on how public policy can promote variety, and it summarizes how we propose to examine the extent to which policy-mixes promote variety generation.

While the framework may serve the policy purpose of monitoring the degree of variety being effectively financed under the policy-mix, it is not the objective of this framework to assess effectiveness of the policy-mix or the degree of complementarity among instruments in the policy-mix. The objective is instead to assess variety in the learning and innovation activities of the public support recipients. Next, we elaborate on the framework.

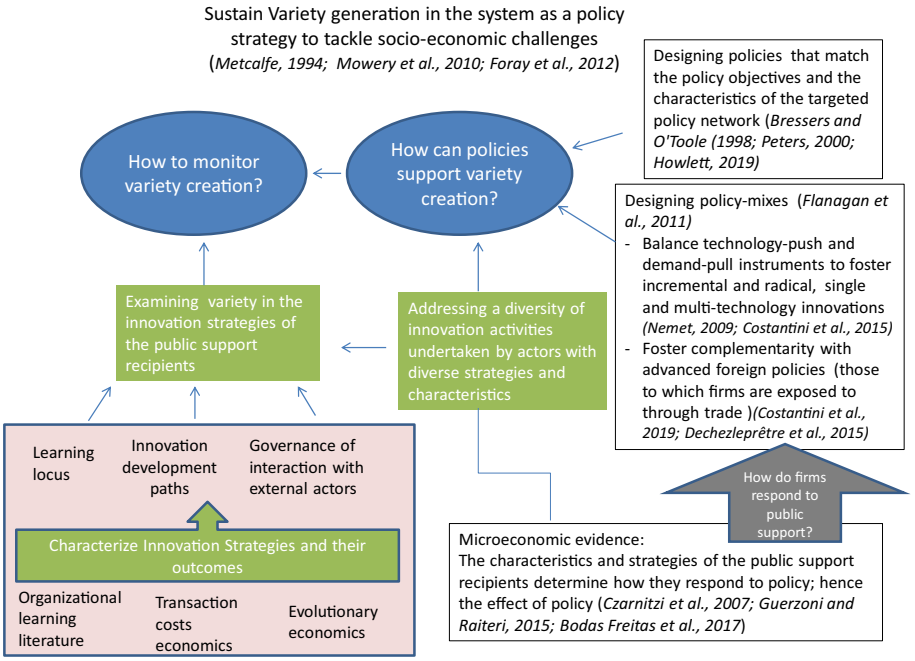

Fig. 1 Graphical representation of the theoretical foundations of the research objective and theoretical framework

3 A framework to analyse variety of innovation strategies sponsored by the policy-mix

Firms may be guided by a plurality of motives when applying for different types of public financial support, and their characteristics and strategies will shape the use they will make of it. In turn, policy implementers will target firms and chose projects that match the programs' objectives and their own agendas. Hence, the innovation activities sponsored by the policy-mix may be a narrow set of the innovation activities required to address the socio-economic challenges that western economies currently face (Mowery et al. 2010; Foray et al. 2012). Thus, it is crucial to monitor the degree to which the policy-mix is sponsoring the generation of variety in the system by reaching a variety of actors and their innovation activities and strategies.

To develop a framework to examine the variety of firms' innovations strategies fostered by the innovation policy-mix, we build on three different streams of literature that have studied innovation patterns associated with specific characteristics and strategies of firms (Fig. 1, light pink area). We rely on the organizational learning literature that stresses that different types of search in the innovation development process influence greatly the innovation behavior and outcomes (Greve 2007; Laursen 2012; Benner and Tushman 2015). We also build on the literature on transaction costs economics and firms' boundaries that have extensively examined the governance decision for sourcing technological know-how (Gulati and Singh 1998; Roy and Sarkar 2016). Finally, we rely on the evolutionary economics that stresses that knowledge is sticky, and consequently leaning and innovative activities are contextual (Nelson and Winter 1982).

Building on these streams of the literature, we propose that the use firms will do of public support depend of three aspects of the firms' innovation activities central to their innovation behavior: a) the innovation search path; b) the forms of governance for technological sourcing; and c) the learning loci in which they operate. Being central to firms' innovation behavior and outcomes, these three aspects of the innovation activities and strategies of firms may influence the use firms will make of the public support. While articulation of these dimensions may not be completely random (Jensen et al. 2007; Stettner and Lavie 2014), the framework aims at mapping variety within each of these three aspects.

We should stress that these three aspects of firms' characteristics and strategies represent somehow axes of asymmetry in the effects of policy and in access of knowledge spillovers. The development stage of the technologies was shown to influence the degree to which their development pace is influenced by different policy instruments (Costantini et al. 2015). Specifically, prior evidence suggests that technology-push and demand-pull policy instruments may have different efficiency in creating variety in innovation paths: exploration of new technologies and the exploitation of mature technologies (Nemet 2009; Costantini et al. 2015). Similarly, prior evidence suggests that the nature of inter-firm relationships, in particular the pattern of inter-sectoral linkages and integration in global value chains (Costantini et al. 2019), as well as the nature of firms' learning loci (Dechezleprêtre et al. 2015; Dechezleprêtre and Glachant 2014; Costantini et al. 2017a) shape the possibility of benefitting from knowledge spillovers and to perform environmentally.

Next, we examine how different business innovation strategies and attributes within each of these aspects may shape the way firms interact with public support for innovation.

3.1 The innovation search paths

The organization innovation literature distinguishes between two types of search in the innovation development process: search aimed at building upon and refining existing knowledge (i.e., exploitation), and search in the technology space for new and more productive techniques and products with unknown demand (i.e., exploration) (March 1991; Gupta et al. 2006; Greve 2007). Both types of search involve learning and innovation, and may be compatible (Greve 2007; Jensen et al. 2007; Stettner and Lavie 2014). The intensity of the firm's exploration and exploitation activities can differ across firm functions and subsystems (Gupta et al. 2006; Raisch et al. 2009).

Innovation development based on exploration and exploitation involves the search for diverse types of information and knowledge and consequently attention on different forms and sources of learning (March 1991; Greve 2007). An emphasis on distant search for new technological knowledge reveals firms' exploratory efforts to explore new avenues for innovation development and to build new competencies and technologies (Stettner and Lavie 2014). Innovation development based on the improvement of internal organizational structures, which encourage learning-by-doing, allows firms to build upon their existing knowledge to adapt and respond quickly to changes in their market and technological environments (Nonaka 1994). While these two paths are apparently opposite to each other, there are firms, often labelled as ambidextrous, that are able to pursue simultaneously exploratory and exploitative search paths for innovation (Brown and Eisenhardt 1997; Raisch et al. 2009).

Foremost, the form in which firms search may influence the manner in which they use the new knowledge. Firms that search pursuing only an exploration or only an exploitation path may use the new knowledge instrumentally in defining the design of new products and the strategic entry in new markets (Song et al. 2005). Ambidextrous firms will have to integrate in some way the new knowledge obtained from the two search processes. Evidence suggests that they will most likely use new knowledge obtained from distant exploratory search to inform and improve existing product and technologies and exploit external spillovers (Song et al. 2005; Furr and Snow 2014). In other words, ambidextrous firms may use knowledge obtained from an exploratory search process to sustain and legitimize their existing technologies and positions in the market, and to prepare the organization to slowly retire from old markets (Song et al. 2005; Furr and Snow 2014).

The motives for firms to apply and use public support may also differ. A strong reliance on exploratory search for technology development can result in a reduced interest in public support for the adoption of technological or organizational best-practice, while heavy reliance on exploitation learning based on experience may discourage firms from applying for public support for distant exploratory search for new knowledge and technologies (Levinthal and March 1993; Tripsas and Gavetti 2000). Ambidextrous firms instead may be able to elaborate applications aimed at exploring new technological directions but also at improving their current products and

organization. Hence, they are more likely to be interested (and have competences) to benefit from a number of policy programs.

3.2 The forms of governance for technological sourcing

The transaction costs and firm organization literatures examine the conditions under which markets, customized contracts and collaborations are relevant organizational arrangements to enable knowledge and technology flows. The appropriateness of these organizational forms is said to depend on the level of the agency and coordination costs, technology uncertainty, and on the appropriation concerns (Artz and Brush, 2000; Gulati and Singh 1998). While the choice of the governance form may depend on the characteristics of the technology development activities, different capabilities are also required to establish and maintain different forms of interactions with external actors in the process of technology development (Felin and Zenger 2014; Roy and Sarkar 2016). Hence, firms with experience with different modes of organization with external actors may induce firms' to apply for different types of public support.

Engagement in collaboration reflects the firm's understanding that knowledge is distributed across different actors and that cooperation may be required to develop a new technology (Hagedoorn et al. 2000). In technological contexts characterized by high levels of uncertainty and rapid knowledge development, collaboration allows firms to exploit the different and complementary resources and competencies of external actors and decreases the risks involved in internal technology development processes (Gulati and Singh 1998; Hoetker and Mellewigt 2009). Experience in developing collaborative innovation seems to be associated with possession of strong technological and organizational capabilities (Gulati and Nickerson 2008; Felin and Zenger 2014). Hence, firms, with experience in sharing knowledge with external actors in the process of technology development, may be more able to propose an original technology development project (also involving key players in related technology domains). In turn, policy-makers and implementers may evaluate these firms highly, based on their greater potential to disseminate their innovative results more broadly (Feldman and Kelley 2006).

Contracting out portions of technological development to other firms and organizations shows that the technologies and know-how available in the market do not match the specific needs of the firm, and that the firm has taken account of the transaction costs involved in leaving some parts of the development to specific technology providers. Hence, firms that contract out parts of the development possess the capabilities to search for technology providers, to set contracts that specify required outcomes, to monitor the activities of providers and to coordinate external and internal innovation development processes and outputs (Gulati and Nickerson 2008; van de Vrande et al. 2009). The use of contracts to manage the interactions involved in technology development reveals firms' concern over appropriation of the innovation developed, which might reduce the motivation to participate in some types of shared knowledge development activities (Feldman and Kelley 2006). Firms that prefer contractual arrangements to accomplish parts of their innovation development processes signal to policy-makers that they have the capability to co-ordinate risky and difficult activities and are unwilling to share their knowledge (Veugelers and Cassiman 1999; Cassiman and Veugelers 2006).

Firms, which rely on both collaboration and contracting out to govern interaction with external actors in the process of technological development, are very well networked and possess competences in developing a mix of relationships with external partners. These firms may have developed trust relationships with some of their collaborators, and eventually dependence relationships with some of their technology suppliers (Faems et al. 2008; Gulati et al. 2012). Hence, they possess capabilities to share and disclosure knowledge in a variety of ways while focusing in preventing unwilling knowledge spillovers (Alexy et al. 2013). These firms signal to policy-makers their ability to select the degree of knowledge sharing according to the type of knowledge development activities and partners involved. Providing public support for these open firms somehow reassures policy-makers/implementers that innovation results will be diffused in different ways to a great number of different actors in the system.

Finally, reliance on internal hierarchies reflects that the firm engages in technological development activities that depend on the sophisticated and complex internal process of organizing resources (Gulati and Singh 1998; Gulati et al. 2012). Through their sophisticated internal resources (product architecture, management and organization, employees' skills) and complex knowledge exchanges, the firm transforms inputs purchased from the market into innovations. These firms rely on the complexity of their internal processes as a form of reducing the risk of potential knowledge spillovers (Gulati and Singh 1998). While these firms may find general public support for innovation useful to search and scan new components and technologies and innovation sources, to standardize design of some innovation activities and to upgrade their innovation capabilities, these firms, however, signal to policy-makers that they would have difficulty in accessing to auxiliary external knowledge sources as well as in diffusing innovation results.

3.3 The locus of learning and innovation development: Firms' technological and market environments

As learning is a contextual activity and innovation opportunities are asymmetric across industries and markets but also across organizational formats (Nelson and Winter 1982), fostering variety in the system may also require sponsoring innovation activities in a variety of learning loci.

Firms active in different industries tend to display specific innovative behaviors as a result of the accumulation of different technological and organizational capabilities (Castellacci 2008). Thus, firms develop specific technological and learning trajectories, rely on diverse technological and market knowledge bases and exploit specific learning processes (Malerba 1992). Pavitt (1984) distinguishes four groups of industry sector—*supplier-dominated, scale-intensive, specialized-supplier* and *science-based*—based on differences in the sources of technology, the user requirements, the direction of technological change and the means of and possibilities for the appropriation of innovation. Hence, the innovation strategies and behaviors of firms depend on their technological learning locus. There is also evidence that firms in different technological learning loci benefit different from public support (Bodas Freitas et al. 2017).

Also, the market environment influences firm behavior and strategies (Hitt et al. 1997; MacGarvie 2006). Participation in local and international markets is associated with the development of different competencies to produce and market, and with

specific network links and, consequently, with access to specific knowledge spillovers. Interaction with local actors seems particularly important for product customization and product diversity for firms that concentrate on the local market and for technological learning (Maskell and Malmberg 1999; Rantisi 2002). For firms active in international markets, it is important to build international reputation (among firms and policy-makers) and establish relationships that will enhance their technological and market reputations (Hitt et al. 1997; Salomon and Shaver 2005). Thus, the strategies of firms active in international markets tend to be influenced by foreign policies (Dechezleprêtre and Glachant 2014; Costantini et al. 2019).

Firms' resources and routines also influence the form in which they respond to market and technological challenges. Firm size is a characteristic of an organization that seems to shape its mode of work organization, routines for knowledge transfer, and ability to invest in innovation (Damanpour 1992; Camisón-Zornoza et al. 2004). Small firms often have limited resources to invest in bringing to the market disruptive technologies in parallel with their core products, while large firms may possess complementary assets that could permit strategic market entries, but they are often reluctant in cannibalizing their existing market (Tripsas and Gavetti 2000; Yang et al. 2014).

In sum, not only the motivation to apply for different types of public support or the benefits that firms reap from public support may depend on the learning loci of the firm, but also some policies may target specifically certain learning loci (specific industries and technological contexts, firms active in specific markets or firms with specific size).

4 Data and methods

4.1 Challenges in applying the framework

The framework elaborated in the previous section can be used to analyze, characterize and compare policy-mixes in terms of the variety of innovation activities that are supported. It permits us to examine variety in multi-level policy-mixes (i.e. firms with similar/diverse innovation strategies being sponsored by different levels of policy governance, over time, geographic or policy spaces), as well as in multi-instrument policy-mixes (i.e. firms with similar/diverse innovation strategies getting support through a variety of different instruments in the policy-mix). In addition, the framework can be used to analyze the extent to which a specific policy design matches the innovation activities supported by one specific program. It can also be used, as we will do in this study, to examine the extent to which the policy-mix sponsors a limited or varied set of firms in terms of their innovation activities and strategies.

Characterization and analysis of the innovation activities supported by the policy-mix can be based on secondary data (Magro and Wilson 2013). For policy-makers, secondary data allow rapid analysis and the development of the competences required to monitor the extent to which the policy-mix promotes variety and to use the results of that analysis for adaptive policy-making. Policy-makers can exploit secondary data provided by firms in their applications for support or program evaluations, or from firm surveys that ask about firms' innovation activities and the benefits provided by public support. In this case, the scope of the analysis is determined by the data available,

which still might provide relevant information on the characteristics of the recipients of public support from different policy-making levels and policy programs.

At a later stage, as policy-makers develop their processes for monitoring variety in the policy-mix in a particular field, specific processes for collecting primary data on the beneficiaries of public support may be implemented. Information could be collected systematically at little additional cost by the inclusion of some targeted question on the documentation and intermediate and final reports/evaluations, which firms are required to submit when applying for, formalizing receipt of and reporting on final use of public support. While, in many cases, public support is directed to a specific project, these questions should aim also at characterizing the firms' innovation and learning activities and, if possible, at comparing the degree of similarity between the sponsored activities and the firm's normal innovation activities. This information would also permit mapping the innovation activities being supported by the different programs, it could show how much the innovation activities supported by programs with different innovation objectives differ, or whether implementation of the policy has diluted the differences in the incentives aimed for by the policy design.

Below, we provide an example of how to operationalize the framework using secondary information. We stress that the objective of the empirical exercise (and of the framework developed) is not to test a set of hypotheses about how firms' innovation strategies relate to a specific policy design. Rather, we want to provide an example on how this framework can be used to characterize the degree of variety of innovation strategies being sponsored by the policy-mix.

4.2 Empirical application of the framework

4.2.1 Data

In France, the policy-mix for innovation is designed and implemented by different policy levels. In the 1980s, two new public actors emerged in France, in the domains of support for innovation, industrial research and technology transfer and SMEs: regional government under the Decentralization Act (1982) and the European Commission through the creation of the Framework Programmes (1984) (Mustar and Larédo 2002). Hence, in France, as in some other European countries, firms are exposed to a diversity of financial support for technology, innovation and restructuring, provided at multiple levels of policy-making; regional/local, national and European authorities (Grande 2001; Kuhlmann 2001; Laranja et al. 2008).

Taking the multi-level policy-mix for innovation available to firms in France, we will examine the extent to which the multi-level policy-mix was sponsoring a variety of innovation strategies in the 2000s. For that purpose, we use secondary data from four waves of Community Innovation Survey (CIS) – 1998-2000, 2002–2004, 2004–2006, and 2006–2008. This data source limits our analysis to manufacturing firms and ignores the roles of other organizations and policies that do not target firms directly. However, to address many of today's socio-economic challenges and, in particular, the development of sustainable growth paths, requires firms to produce, organize and market their products and technologies in different ways (Hargadon 2010; Mowery et al. 2010). CIS data enable access to information on a large population of firms. It should be noted that the French CIS achieves an over 80% response rate. Furthermore, the CIS survey

includes questions the responses to which allow us to proxy those aspects of firm innovation activities that are part of our framework: the innovation development paths, the forms in which interaction with external actors for knowledge development are organized and governed, and the locus of the learning processes.

4.2.2 Measures of benefit from public support

Our data provide information on whether or not the firm received public support, but we do not have information on firms that applied for and did not receive support.[1] The CIS asks firms whether they received public innovation support from different levels of government (local, national, European organization). It asks whether the firm used public support provided by local government (LOCAL), by central government or a national agency (CENTRAL) and/or by a European organization (EUROPEAN). Hence, our analysis is limited to whether the financial support for innovation provided by Local, National and European policy programs addresses similar or different learning activities in firms. Table 1 provides information on the number firms in our sample that, in the four periods, responded to the survey, and the share of the firms that received public innovation support from different levels of government in France.

The data show that, in the period 1998 to 2008, financial support from innovation from Central government reached more firms than the support provided by Local government or European authorities. Still, after 2004, the relevance of Central public support decreased while Local public support increased. The share of firms that received support from at least one policy level decreased throughout the 2000s and, especially, after 2006. However, this reduction was not accompanied by a reduction in the number of firms that received support from more than one level of policy-making.

4.2.3 Measures of firms' strategies and learning loci

Based on information from the CIS, we computed the share of turnover dedicated to intramural R&D as the ratio of total expenses on intramural R&D on total sales. In addition, we counted the number of different innovation activities in which the firm invested (except for R&D). The firm could declare to have invested in personnel training, machinery, production engineering supporting implementation of new product or process, and marketing programs. We use these two measures to characterize a firm's investment in widening the search space, and in refining and exploiting its existing knowledge, and consequently to create three variables that distinguish firms' search paths for innovation. The variable *Explorer* takes the value 1 if the firm spends more than 3% of its turnover in internal R&D activities but invests in two or fewer other auxiliary innovation activities; 0 otherwise. The variable *Exploiter* takes the value 1 if the firm invests in more than two auxiliary innovation activities, but spends less than 3% of turnover in internal R&D activities. The variable *Ambidextrous* takes the value 1 if the firm spends more than 3% of its turnover in internal R&D activities and invests in

[1] Firms that receive financial public support are those that (first) self-select by applying for the support and (second) are selected by policy-implementers. The selection criteria in both cases reflect the design of the public support and the firms' innovation strategies. Public support for innovation is awarded to those firms the characteristics and capabilities of which comply with policy requirements.

Table 1 Share of manufacturing firms by industry activity that benefitted from public support provided by organizations at local, central-national and by European levels, in France, 2002–2008

	1998–2000		2002–2004		2004–2006		2006–2008		Total
Local	221	9%	283	9%	305	11%	430	13%	1239
National	618	26%	708	22%	368	13%	538	16%	2232
European	214	9%	234	7%	299	11%	246	7%	993
No support	1644	69%	2413	74%	2030	73%	2702	79%	8789
Support from 1 level of policy-making	500	21%	590	18%	580	21%	371	11%	2041
Support from 2 levels of policy-making	179	7%	190	6%	172	6%	222	6%	763
Support from 3 levels of policy-making	65	3%	85	3%	16	1%	133	4%	299
Total	2388	100%	3279	100%	2798	100%	3428	100%	11,893

three or more auxiliary innovation activities. The base category includes then firms that do not follow strongly well-defined exploratory or exploitative search path for innovation.

To characterize the forms in which firms organize and govern exchange and interaction with external actors for innovation development, we use information on a firm's reliance on collaboration for innovation development, and on whether the firm contracts out technology development. Based on these measures, we create three variables. The variable *Collaborator* takes the value 1 if the firm reports to have collaborated with external actors for innovation development but have not contracted out research activities. The variable *Outsourcer* takes the value 1 if the firm reports to have contracted out to external actors R&D but not collaborated. The variable *Open* takes the value 1 if the firm reports to have contracted out and collaborated on R&D activities with external actors. The base category includes then firms that relied mostly on internal technological development (including or not formal R&D activities) and on market available technologies.

Finally, to characterize the firm's learning loci, we use six variables. Five dichotomous measures proxy for the firm's market and industrial sector. The variable *International* takes value 1 if the firm is active in international markets, and 0 if it only operates in the national market. The variables *Science-based*, S*pecialized-supplier*, S*cale-intensive* and S*upplier-dominated* report firms industrial activity as in Pavitt (1984). The variable *Size* measured as logarithm of number of employees proxies for firm size. Table 2 summarizes the measures used in the empirical analysis.

4.3 Estimation strategy

We proceed in two steps. First, we examine how the strategies and characteristics of firms are associated with benefit from LOCAL, NATIONAL and EUROPEAN public financial support for innovation. For this purpose, we estimate the probability to benefit from each public support, using a random effects probit with time fixed effects. To account for learning effects in getting access to public support, we include information on whether the firm received in the prior period LOCAL, CENTRAL and EUROPEAN public support. Then, we use the Wald chi square test to compare the effect of the

Table 2 Measures used to examine variety of innovation activities within the policy mix in France from 1998 to 2008

Dimensions of the model	Different aspects	Description of the measures
Learning locus	Locus of market learning	INTERNATIONAL takes value 1 if the firm's is active in the international market; 0 otherwise. (For the period 1998–2000 this variable measures instead if the most significant market is the international market).
	Locus of technological learning	Firm's sectoral activity, using Pavitt's (1984) taxonomy: SUPLIER--DOMINATED, SCALE-INTENSIVE; SPECIALIZED-SUPLLIERS; SCIENCE-BASED.
	Locus of organizational learning	SIZE: logarithm of firm's total number of employees
Paths of innovation development	Exploratory path: Firm's efforts to widen the search space for innovation,	EXPLORER takes the value 1 if the firm spends more than 3% of its turnover in internal R&D activities but invests in two or fewer other auxiliary innovation activities; 0 otherwise.
	Exploitative path: Firm's draw on a variety of efforts to improve their knowledge and technologies	EXPLOITER takes the value 1 if the firm invests in more than two auxiliary innovation activities, but spends less than 3% of turnover in internal R&D activities.,
	Both Exploratory and exploitative paths	AMBIDEXTROUS takes the value 1 if the firm spends more than 3% of its turnover in internal R&D activities and invests in three or more auxiliary innovation activities.
Organization of the interaction with external actors for innovation development	Firm's engagement in collaboration for innovation	COLLABORATOR takes the value 1 if the firm reports to have collaborated with external actors for innovation development but has not contracted out research activities.
	Firm's experience in contracting	OUTSOURCER takes the value 1 if the firm reports to have contracted out to external actors research and technology development activities but not collaborate with them.
	Firm's reliance on a variety of open governance strategies including both collaboration and outsourcing.	OPEN takes the value 1 if the firm reports to have contracted out and collaborated on research and development activities with external actors.

different firms' strategies and characteristics in explaining benefit from public support provided by different levels of policy-making.

Second, we examine the extent to which the degree of variety of the innovation activities supported by each level of policy-making increased or decreased over time. For that purpose, we estimate for each year the probability of benefiting from public support provided by different levels of policy-making, and we compare the coefficients over time using Wald Chi square tests.

5 Results

5.1 Variety of firms' strategies sponsored in the policy-mix

Table 3 reports random effects estimation of the probability to benefit from LOCAL, CENTRAL and EUROPEAN financial public support for innovation activities.

LOCAL public support has been sponsoring mostly the innovation activities of *Ambidextrous* firms, but also of *Explorers* and *Exploiters* that invest strongly in either exploration and exploitation paths for innovation development. It has benefitted significantly more *Outsourcers* and *Open* firms than firms that used other forms of governance. The likelihood of benefiting from LOCAL support is positively associated with prior use of Local, Central and European support, suggesting that access to the support was facilitated if firms had early developed capabilities in writing proposals and in dealing with application processes. In relation to 2004, the probability of getting support is higher in 2006 and 2008.

CENTRAL financial support has reached mostly *Ambidextrous* firms, as well as *Open* firms. In addition, firms that operate in *International* markets seem more likely to have used this support. The probability of getting financial support for innovation from CENTRAL government is higher for firms that have benefitted in the period before of Local or European support. In 2006, the probability to benefit from CENTRAL support was smaller than in any other period.

EUROPEAN support has mostly sponsored the innovation activities of *Ambidextrous* firms, *Explorers*, as well as *Open* firms. The probability of benefitting from EUROPEAN support is higher for *Large* firms and for firms that in the prior period have benefitted public support. In 2006, the probability to access to EUROPEAN support was higher than in any other period.

We focus now on the differences in the strategies and firm characteristics supported by the different levels of policy-making. Wald Chi square tests suggest that LOCAL public support differs significantly from the CENTRAL by reaching more extensively the innovation activities of *Exploiters* and *Ambidextrous*. LOCAL support differs from EUROPEAN support by targeting *Small* firms. EUROPEAN support differs from CENTRAL one by reaching more extensively *Ambidextrous* firms. Finally, the three levels of public support differ significantly in terms of the firm *Size* they address as well as the extension of recurrent public sponsored firms among the beneficiaries.

Overall, these results suggest some overlap of the strategies and activities sponsored by the different levels of policy-making. In particular, all the three financial support are more likely to be sponsoring the innovation activities of *Ambidextrous* and *Open* firms.

Table 3 Probability of benefiting from LOCAL, CENTRAL and EUROPEAN support: Probit estimation of with random effect. Wald Chi2 test comparing coefficients

				Wald Chi2 Test			
	LOCAL	CENTRAL	EUROPEAN	LOCAL CENTRAL	LOCAL EU	CENTRAL EU	LOCAL-CENTRAL-EU
L_Local	**1.018*** **	**0.544*** **	**0.361*** **	13.842***	23.161***	1.947	66.323***
	[0.094]	[0.086]	[0.099]				
L_Central	**0.165** **	0.105	**0.267*** **	0.318	0.803	2.351	2.348
	[0.081]	[0.069]	[0.080]				
L_EUROPEAN	**0.513*** **	**0.387*** **	**1.216*** **	0.954	29.109***	46.454***	81.677***
	[0.097]	[0.085]	[0.087]				
Size	0.005	0.039	**0.132*** **	0.706	8.125***	5.088**	24.245***
	[0.031]	[0.026]	[0.032]				
International	**0.279***	**0.239** **	0.253	0.042	0.013	0.005	0.042
	[0.155]	[0.119]	[0.164]				
Science-based	−0.163	0.043	0.042	2.191	1.735	0.000	5.230
	[0.107]	[0.089]	[0.113]				
Specialized-suppliers	−0.066	0.114	−0.049	1.377	0.010	1.032	0.029
	[0.118]	[0.098]	[0.127]				
Scale-intensive	−0.096	0.093	0.008	2.162	0.509	0.398	1.547
	[0.099]	[0.082]	[0.107]				
Explorer	**0.282** **	**0.183***	**0.297** **	0.350	0.007	0.478	0.020
	[0.131]	[0.104]	[0.128]				
Ambidextrous	**0.611*** **	**0.199** **	**0.473*** **	8.572***	0.839	4.007***	2.488
	[0.109]	[0.089]	[0.104]				
Exploiter	**0.224** **	0.017	0.071	3.342*	1.445	0.221	4.437

Table 3 (continued)

				Wald Chi2 Test			
	LOCAL	CENTRAL	EUROPEAN	LOCAL CENTRAL	LOCAL EU	CENTRAL EU	LOCAL-CENTRAL-EU
	[0.089]	[0.070]	[0.091]				
Open	**0.341*** **	**0.366*** **	**0.362*** **	0.036	0.020	0.001	0.062
	[0.104]	[0.081]	[0.106]				
Collaborator	0.110	0.081	0.167	0.031	0.095	0.264	0.289
	[0.130]	[0.103]	[0.132]				
Outsourcer	**0.309*** **	0.105	0.084	1.977	1.799	0.019	5.559
	[0.113]	[0.091]	[0.124]				
2008	**0.274*** **	−0.101	−0.041	10.633***	5.674**	0.261	17.838***
	[0.092]	[0.069]	[0.095]				
2006	**0.259*** **	**−0.497*** **	**0.265*** **	46.481***	0.002	47.888***	0.007
	[0.086]	[0.070]	[0.085]				
Constant	−2.411***	−1.654***	−3.108***				
	[0.252]	[0.191]	[0.254]				
lnsig2u	−2.875*	−9.937	−12.941				
	[1.670]	[13.972]	[26.218]				
Observations	3084	3084	3084				
Number of firms	1908	1908	1908				
Degrees of Freedom	16	16	16				
Wald chi2	545.55***	282.9***	359.47***				
log Likelihood	−906.4	−1315	−820.9				

Standard errors in brackets; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

5.2 Evolution on the variety of innovation activities sponsored during the 2000s

The objective here is to provide a clear picture of the strategies and characteristics being sponsored in each sub-period. Hence, we estimate the probability of benefitting from LOCAL, CENTRAL and EUROPEAN public support in each period. We estimate the robust probit using a conditional mixed process, which allows the error terms to be linked and the dependent variable related. Next, we compute the Wald chi square tests, comparing coefficients over the four periods. Results are reported in Table 4. In the annex A Table 5, we report the estimation of the same models but add the lag of the LOCAL, CENTRAL and EUROPEAN, which, while providing less unbiased coefficients on the effect of each characteristic on the probability to get the support, also provides a less clear description of the strategies and characteristics being sponsored in each sub-period.

In terms of the innovation paths supported, during the 2000s, the innovation activities of *Ambidextrous* firms were more likely sponsored by any levels of policy-making, while *Explorers* and *Exploiters* seem to have been able to benefit from public sponsoring for their activities from different levels of policy-making. In the early 2000s, LOCAL support (columns 1, 4) reached mostly the innovation activities of *Ambidextrous* and *Exploiters*, EUROPEAN (columns 3, 6) support targeted especially *Ambidextrous* and *Explorers*, while CENTRAL support (columns, 2, 5) sponsored firms with a variety of (well-defined) paths for innovation. In the mid-2000s, the three levels of policy-making sponsored mostly *Ambidextrous* and *Explorers*. In the late 2000s, LOCAL policies (column 10) encouraged mostly *Ambidextrous* and *Exploiters*, while CENTRAL and EUROPEAN (columns 11, 12) policies encourage all the three strongly well-defined innovation paths.

Concerning the governance of the exchange with external actors, during the 2000s, the innovation activities of *Open* firms were strongly supported by all the levels of policy-making, in line with results in Table 3. Still, LOCAL support (columns 1, 4, 7, 10) also favored significantly *Outsourcers*, while EUROPEAN in the first and last sub-periods (columns 3, 12) sponsored significantly *Collaborators*.

In terms of learning loci, results suggest that, during the 2000s, while some efforts were made to reach a diverse set of firms, some specific technological learning loci remained neglected. In the early 2000s, LOCAL support (columns 1,4) reached mostly *Small* firms active in *Supplier-dominated* or *Scale-intensive* sectors, while *Large International* firms were instead targeted by European policies (columns 3,6). During the mid and end 2000s, LOCAL support (columns 7, 10) continued to benefit these learning loci, but these were each time less favored together with scale-intensive sectors. CENTRAL support (column 11) encouraged each time more the innovation activities of *International* firms. EUROPEAN support (column 9, 13) seems to have become each time more difficult to be used by *Specialized-suppliers* and *Scale-intensive* firms, while slightly less difficult for *Small* firms active in *National* markets.

We focus now on the significant time differences for each level of public support. During the 2000s, LOCAL support (column 13) increasingly favured *Open* firms. *Specialized-suppliers* and, to a lesser extent, *Science-based* firms, which, in the beginning of the period, were less likely to get LOCAL support, became as likely as firms in other industries to get the support.

Table 4 Probability of benefitting from LOCAL, CENTRAL and EUROPEAN support: Probit estimation of using a conditional mixed process. Wald Chi2 test comparing coefficients over time

	1998–2000			2002–2004			2004–2006	
	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL
	1	2	3	4	5	6	7	8
Size	−0.095***	−0.035	0.184***	−0.059**	−0.076***	0.121***	−0.017	0.007
	[0.030]	[0.024]	[0.035]	[0.023]	[0.020]	[0.026]	[0.028]	[0.026]
International	0.022	0.085	0.274***	−0.087	0.049	0.033	0.070	−0.193**
	[0.085]	[0.065]	[0.093]	[0.088]	[0.075]	[0.108]	[0.097]	[0.082]
Science-based	−0.453***	−0.239**	−0.117	−0.197**	0.013	0.078	−0.190**	−0.167*
	[0.121]	[0.095]	[0.134]	[0.096]	[0.078]	[0.102]	[0.093]	[0.087]
Specialized Suppliers	−0.452***	−0.028	−0.157	−0.298***	0.267***	−0.010	−0.195*	−0.243**
	[0.131]	[0.099]	[0.137]	[0.109]	[0.081]	[0.112]	[0.106]	[0.102]
Scale-intensive	−0.124	0.042	0.004	0.006	0.117*	0.090	0.017	−0.137*
	[0.102]	[0.087]	[0.130]	[0.082]	[0.068]	[0.095]	[0.082]	[0.075]
Explorer	0.077	0.409***	0.423***	0.329***	0.320***	0.248**	0.131	0.060
	[0.131]	[0.092]	[0.127]	[0.104]	[0.083]	[0.113]	[0.126]	[0.110]
Ambidextrous	0.584***	0.588***	0.744***	0.570***	0.513***	0.570***	0.675***	−0.227**
	[0.116]	[0.093]	[0.116]	[0.100]	[0.081]	[0.100]	[0.098]	[0.113]
Exploiter	0.282***	0.157**	0.153	0.101	0.060	−0.038	0.017	−0.182**
	[0.095]	[0.075]	[0.107]	[0.082]	[0.065]	[0.089]	[0.081]	[0.074]
Open	0.438***	0.644***	0.568***	0.359***	0.729***	0.421***	0.515***	−0.090
	[0.104]	[0.082]	[0.115]	[0.090]	[0.070]	[0.085]	[0.092]	[0.084]
Collaborator	0.193	0.358***	0.476***	0.046	0.268***	0.162	0.308***	−0.061
	[0.118]	[0.089]	[0.123]	[0.122]	[0.092]	[0.116]	[0.116]	[0.108]

Table 4 (continued)

	1998–2000			2002–2004			2004–2006	
	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL
Outsourcer	0.255**	0.231**	0.096	0.224***	0.390***	−0.182*	0.276***	0.111
	[0.119]	[0.093]	[0.159]	[0.087]	[0.071]	[0.107]	[0.094]	[0.077]
Constant	−0.974***	−0.895***	−3.076***	−1.248***	−1.036***	−2.436***	−1.560***	−0.814***
	[0.157]	[0.132]	[0.231]	[0.125]	[0.108]	[0.168]	[0.160]	[0.135]
Observations	2107			3279			2797	
Degrees of Freedom	33			33			33	
Wald Chi2	317.43***			394.57***			248.5***	
log Likelihood	−2211			−2985			−2745	

	2004–2006	2006–2008			Wald Chi2 Test		
	EUROPEAN	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL	EUROPEAN
	9	10	11	12	13	14	15
Size	0.131***	−0.058***	0.015	0.071***	8.820**	73.728***	33.678***
	[0.028]	[0.021]	[0.019]	[0.023]			
International	0.085	0.062	0.170**	0.033	2.557	6.514*	11.520***
	[0.105]	[0.075]	[0.073]	[0.088]			
Science-based	−0.079	−0.155*	0.051	−0.057	20.520***	4.378	0.012
	[0.095]	[0.084]	[0.080]	[0.089]			
Specialized Suppliers	−0.118	−0.180*	0.056	−0.372***	17.262***	58.436***	9.927**
	[0.109]	[0.093]	[0.090]	[0.118]			
Scale-intensive	0.090	−0.165**	0.091	−0.176**	0.434	33.370***	7.283*

Table 4 (continued)

	2004–2006	2006–2008			Wald Chi2 Test		
	EUROPEAN	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL	EUROPEAN
	[0.085]	[0.071]	[0.070]	[0.083]			
Explorer	0.108	0.136	0.210**	0.248**	0.008	14.582***	7.832**
	[0.131]	[0.096]	[0.089]	[0.102]			
Ambidextrous	0.757***	0.626***	0.739***	0.608***	1.279	12.047***	1.124
	[0.098]	[0.093]	[0.087]	[0.102]			
Exploiter	0.006	0.222***	0.201***	0.193**	2.522	0.808	0.807
	[0.084]	[0.073]	[0.069]	[0.083]			
Open	0.307***	0.552***	0.580***	0.382***	7.376*	98.790***	12.626***
	[0.089]	[0.079]	[0.074]	[0.086]			
Collaborator	0.003	0.164*	0.113	0.226**	0.612	13.887***	15.228***
	[0.126]	[0.088]	[0.085]	[0.099]			
Outsourcer	0.122	0.213**	0.130	−0.024	0.144	35.324***	0.055
	[0.095]	[0.087]	[0.083]	[0.106]			
Constant	−2.302***	−1.225***	−1.675***	−2.052***			
	[0.166]	[0.104]	[0.104]	[0.125]			
Observations		3364					
Degrees of Freedom		33					
Wald Chi2		355.17***					
log Likelihood		−2784					

Robust standard errors in brackets*** $p < 0.01$, ** $p < 0.05$, * $p < 0.2$

Concerning the CENTRAL public support, the Wald Chi square tests (column 14) hint at the notion that the period 2004–2006 marks a change in its design and/or implementation. Moreover, they suggest that, in the period 2004–2006, CENTRAL support (column 8) targeted a very peculiar type of firms that had not been addressed before or after. Before and after 2006, CENTRAL support supported mostly *Explorers*, *Ambidextrous*, as well as *Open* firms. In 2004, *Small* firms were more likely to get the support, but the same was not found in any other period. In 2000*, Science-based* firms were less likely to get CENTRAL support when compared to *Supplier-dominated* firms. In 2004, *Specialized-suppliers* and *Scale-intensive* firms were the targeted technological learning loci. In 2008, no specific technological learning locus was targeted but it seems to have favored firms active in *International* markets. Hence, if we exclude the period 2004–2006, CENTRAL support seems to have evolved mostly in terms of the learning loci supported.

Finally, during the 2000s, EUROPEAN support (column 15) increasingly favored *Open* firms and, to a lesser extent, also *Ambidextrous* firms. *Explorers* and *Large* firms, which in early 2000s were strongly favored over *Small* firms with non-defined innovation search, kept being favored recipients of the EUROPEAN policies but significantly less. Somehow similar, *Collaborators,* which in early 2000s were preferred over firms that relied on market transactions or on internal hierarchy, in the mid-2000s, were not any longer preferred. From 2004, firms active in *International* markets have been no longer specifically targeted by the support. In the late 2000s, *Specialized-suppliers* and *Scale-intensive* firms were less likely to benefit from the support.

Overall, during the 2000s, variety of the innovation activities and strategies reached by the three levels of policy-making does not seem to have increased. Variety in the innovation paths sponsored may even have decreased as CENTRAL and EUROPEAN support increasingly benefitted *Ambidextrous* firms. Similarly, variety may have decreased in the forms of governance sponsored as *Open* firms were increasingly favored by all levels of policy-making. In terms of learning loci sponsored, while LOCAL support increasingly sponsored a variety of technological and industrial areas, EUROPEAN support has increasingly neglected some specific technological learning loci and CENTRAL support increasingly benefiting specific market learning locus.

5.3 Discussion

Evidence points to a relative (increasing) overlap of the innovation strategies sponsored by the three levels of policy-making during the 2000s and, consequently to a slight deterioration in the variety of innovation activities in the policy-mix.

During the 2000s, the three levels of policy-making increasingly sponsored with preference *Open* and *Ambidextrous* firms. These firms have capabilities and resources to search for innovation opportunities by investing in widening their knowledge basis while investing in a number of auxiliary activities to exploit innovation opportunities from their current knowledge and technologies, as well as for coordinating knowledge exchange with external actors through a multiplicity of forms. Firms with well-defined but less integrated innovation strategies such as *Explorers*, *Exploiters*, *Collaborators* or *Outsourcers* still had more chances to get their innovation activities public sponsored by some levels of policy-making, when compared to firms that do not rely on well-defined strategies for innovation search and for knowledge exchange with external actors. Concerning variety of the learning loci sponsored, during the

2000s, LOCAL support kept reaching with preference *Small* firms, but increasingly fewer firms active on specific markets or technological sectors. Instead, despite some advances during the 2000s, EUROPEAN and CENTRAL support still reached firms with a preference in some specific learning.

These results are somehow in line with prior research on French innovation support and the evolution of the public policy scene in France. In 1982, the law on decentralization supported transfer to the regions of responsibility and resources for policy implementation and design. Ministerial regional offices, local agencies and a budget (Contrat Plan Etat-région - CPER) were established to accomplish this decentralization (Cole 2006; OECD 1993, 2000a, 2000b). Particularly important in this process was the CPER, which made government and regional authorities partners for the financing and selecting of common priorities for regional development. The CPER allocates funds to local organizations and defines their specific uses (Cole 2006; OECD 1993, 2000a, 2000b). Thus, unlike other European countries, the devolution of responsibility in the French administration, to sub-national public authorities, is characterized by decentralization of central state agencies (Cole 2006).

In the context of public support for innovation and research, from the 1980s until the early 2000s, under a political commitment to decentralize budgets and responsibilities, support was implemented at the regional and local levels by an increasing number of organizations. In addition to public funding for industrial renewal, local firms and especially small and medium sized enterprises were able to benefit from the ANVAR reimbursable financial aid for research or from the ANRT support for a collaborative PhD program, or from CRITT support for technology transfer (Crespy et al. 2007; Bodas-Freitas and von Tunzelmann 2008). Given the large number of organization and the overlaps in their functions combined with the need for public support to keep abreast of technological and management developments, from the mid-1990s, the central government launched several new programs (Crespy et al. 2007; Bodas-Freitas and von Tunzelmann 2008). These Central government programs were aimed at encouraging networking and collaboration among the different local policy actors, to improve accessibility, decrease the complexities of public support for firms, encourage the development of technological and business-to-business services together with best-practice technologies, and signal the areas where local frameworks are more appropriate.

Indeed, Bodas-Freitas and von Tunzelmann (2008) show that, in the early 2000s, French Local public support was based more on financial subsidies for collaborative research, technological development and technology adoption, and Central government support was directed towards encouraging new market and technological developments through open calls ('as well as the development of tools to monitor public business services provision or to support management capabilities of firms' (Bodas-Freitas and von Tunzelmann 2008, p.1459). The European Framework programs sponsor research and networking activities among mostly large firms involved in research activities (Laredo 1995).

In the mid-2000s, several legal changes strengthened the decentralization of public innovation policy. The 2003 Constitutional Reform and the 2004 Decentralization Act included the principle of financial autonomy of local authorities and allowed public support to vary across the country (Cole 2006). This resulted, for example, in French regions being able to bid for and control the management of structural funds (Cole 2006; Crespy et al. 2007). In 2005, Regional Councils were given explicit responsibility for economic development and efforts were made to clarify responsibilities and rationalize

local and regional administration. For example, in 2005, the local ANVAR network merged with the development bank – *Banque du développement des petites et moyennes enterprises* (BDPME) – and formed the OSEO, the mission of which since has been to support technological development and innovation, SMEs and new firm creation and development (Crespy et al. 2007). In addition, several different national agencies, such as ANR, the national research foundation, have been created to govern research, innovation and technology transfer in coordination with local agencies (Cole 2006; Crespy et al. 2007). For example, OSEO, in collaboration with ANR, launched a national competition for the creation of technology-based companies (Crespy et al. 2007). At the same time, calls to support *pôles de compétitivité* were launched nationally to create competitive industrial clusters based on synergies between local research organizations and firms. Firms in these clusters are eligible for several types of direct aid and are prioritized in applications for other types of support. In addition, local partners support local firms to apply for European support for innovation (Crespy et al. 2007).

These legal and organizational changes that occurred in 2004–5 seem to explain the changes observed in the innovation strategies sponsored in the late-2000s. While until the early 2000s, a fuzzy 'division' of the innovation policy objectives across the levels of policy-making might be perceived, this seems to have become even more ambiguous from the mid-2000s. As local authorities and agencies extended their policy portfolios and policy domains, they could reach a greater variety of firms, and they would also target those that are favored by the other levels of policy-making. By the end of the 2000s, benefit of LOCAL support in the previous period improved significantly the probability to use of public support provided by any level of policy-making, while prior benefit from CENTRAL support does no longer enhance the probability of getting any support (see Table in Annex A Table 5). As Central government focused on setting the direction, for research and innovation and on developing networks, its support was then mostly targeting the innovation activities of *Ambidextrous* and *Open* firms, which were also targeted by Local and European support.

In sum, it seems that as Local policy portfolios increased, and Local, Central and European public support for innovation became more similar (sponsoring pre-competitive research, technology-intensive start-ups, collaborative research and network building). Hence, we cannot observe an increase in variety in the innovation strategies fostered by the policy-mix (as data suggests in Table 1).

6 Conclusions

Several studies claim that to address current economic and social challenges requires a range of public instruments for promoting multiple of technologies, business models and institutions. However, little attention has been paid to whether and how the policy-mix might actually provide incentives for a variety of innovation activities. The present study addressed this gap in the innovation policy and policy-mix literatures by proposing that, by examining the characteristics and innovation strategies of the recipients of public innovation support, one can get insights into the variety of innovation incentives fostered by the policy-mix. Our framework propose that three different aspects of firms' innovation strategies are relevant to differentiate firms' potential use of the public support: the innovation search path, forms of governance for technological sourcing,

and their learning loci. To show the practical utility of this framework, we presented an application using data from the French CIS.

Empirical evidence showed that, during the 2000s in France, we cannot observe an increase in variety in the innovation strategies fostered by the policy-mix. The three levels of policy-making increasingly sponsored with preference *Open* and *Ambidextrous* firms. Firms with well-defined but less integrated innovation strategies could still get their innovation activities public sponsored by some levels of policy-making, but each time with few chances. Hence, the different multi-level policy resources are being used mostly by firms that follow well defined and integrated strategies for innovation search and for reaching their partners in the ecosystem. Ironically, despite being a caricature of the organizational ability to deal with variety, by being able to cope with several different activities, the innovation efforts of *Ambidextrous* and *Open* firms could not capsulate the variety of knowledge and business experiments needed in an economy. Their activities are well embedded on existing knowledge bases and markets which is why they can perform simultaneously these apparently different activities and strategies (Levinthal and March 1993; Raisch et al. 2009). Hence, to tackle socio-economic challenges, it is important to address also firms with less integrated innovation strategies, which may signal lower possibilities of short-term commercialization and diffusion of new knowledge.

When using this or an adapted version of this framework to examine the extent to which the policy-mix promotes variety generation in the system, it is important to note the following. First, in different institutional set ups or over time in institutional set ups that experience severe institutional changes, policy-mixes with similar designs might be able to target firms with different characteristics and innovation strategies. In addition, firms' activities can shape innovation policy as well (Teubal and Andersen 2000). Therefore, this approach to the examination of variety in innovation policy-mixes, would benefit from being complemented by policy design analysis.

Second, the data and measures used to characterize and/or compare policy-mixes influence the nature of the insights obtained. In our examples, we used secondary information on the firms' innovation activities. This allowed us to characterize the innovation activities that are promoted publicly, but limits our understanding of whether and how firms adapt their strategies to access the available public support. With the primary appropriate data, we could use information on firms' intentions to use different types of public support, for example, whether they approached public support providers/platforms with the intention to learn more and access public support, whether firms' realized that the support available was not worth applying for, or whether firms applied but were not granted support.

Third, this framework could be fine-tuned to address specific policy objectives. In addition to the specifics of the policy objective, the framework could be customized to the specific socio-economic set up and the evolution of technological and innovation strategies and business models. This could be achieved via a series of exercises aimed at identifying specific innovation strategies, translating policy objectives and policy design into innovation strategies to be targeted, and drawing on innovations strategies being targeted effectively to inform the redesign of policy.

Acknowledgements This study had its origins on a series of discussions with Nick von Tunzelmann, which started at the end of-2009 and continued for a while after that. Unfortunately, I had to pursue alone with the paper project since then, but Nick's inspiring suggestions set the pace going. To his memory this paper is dedicated. Besides Nick's contribution, I would like to thanks the comments and suggestions of an anonymous reviewer. The usual disclaimers apply.

Annex A

Table 5 Probability of benefitting from LOCAL, CENTRAL and EUROPEAN support: Probit estimation of using a conditional mixed process. Wald Chi2 test comparing coefficients over time

	2002–2004			2004–2006			2006–2008			Wald Chi2 Test		
	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL	EUROPEAN
	1	2	3	4	5	6	7	8	9	10	11	12
L_Local	0.490***	0.197	0.088	1.058***	−0.414*	0.043	1.244***	1.176***	0.736***	31.552***	36.751***	18.177***
	[0.171]	[0.171]	[0.185]	[0.156]	[0.239]	[0.192]	[0.136]	[0.134]	[0.146]			
L_Central	0.316**	0.857***	0.372***	0.392***	−0.102	0.416***	−0.223	−0.107	−0.080	17.065***	65.053***	12.603***
	[0.136]	[0.114]	[0.141]	[0.124]	[0.144]	[0.124]	[0.185]	[0.153]	[0.172]			
L_EUROPEAN	0.686***	0.515***	1.244***	0.279*	0.014	1.334***	0.466***	0.453***	1.037***	2.595	0.188	2.362
	[0.166]	[0.141]	[0.162]	[0.164]	[0.207]	[0.159]	[0.142]	[0.138]	[0.145]			
Size	−0.070	0.043	0.214***	−0.011	0.080*	0.065	0.040	0.018	0.114**	5.685	0.376	3.609
	[0.060]	[0.051]	[0.075]	[0.047]	[0.044]	[0.047]	[0.052]	[0.046]	[0.057]			
International	0.258	0.607*	omitted	0.148	−0.019	0.257	0.245	0.456*	0.024	0.004	0.462	
	[0.307]	[0.329]		[0.212]	[0.176]	[0.238]	[0.216]	[0.241]	[0.242]			
Science-based	−0.306	0.038	0.318	−0.140	−0.178	−0.097	−0.054	0.123	−0.053	2.495	0.365	4.396
	[0.216]	[0.192]	[0.248]	[0.170]	[0.149]	[0.175]	[0.162]	[0.142]	[0.182]			
Specialized Suppliers	−0.387	0.433**	0.119	−0.040	−0.354**	−0.138	0.167	0.230	−0.037	9.618**	1.651	0.612
	[0.244]	[0.199]	[0.261]	[0.181]	[0.171]	[0.181]	[0.188]	[0.176]	[0.241]			
Scale-intensive	−0.077	0.295	0.033	−0.065	−0.195	0.028	−0.111	0.158	−0.071	0.050	1.053	0.362
	[0.202]	[0.180]	[0.250]	[0.164]	[0.140]	[0.161]	[0.157]	[0.139]	[0.176]			
Explorer	0.569**	0.242	0.015	0.268	0.143	0.119	0.163	0.138	0.598***	4.733	0.433	9.070**
	[0.234]	[0.198]	[0.255]	[0.199]	[0.181]	[0.207]	[0.212]	[0.167]	[0.205]			

Table 5 (continued)

	2002–2004			2004–2006			2006–2008			Wald Chi2 Test		
	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL	EUROPEAN	LOCAL	CENTRAL	EUROPEAN
Ambidextrous	0.674***	0.268*	0.045	0.487***	−0.228	0.593***	0.599***	0.556***	0.590***	0.244	4.363	11.954***
	[0.195]	[0.159]	[0.192]	[0.154]	[0.169]	[0.154]	[0.175]	[0.149]	[0.197]			
Exploiter	0.431**	−0.067	−0.159	0.049	−0.124	0.085	0.213	0.132	0.162	2.648	3.535	5.800
	[0.178]	[0.132]	[0.169]	[0.136]	[0.115]	[0.130]	[0.147]	[0.119]	[0.160]			
Open	0.226	0.660***	0.802***	0.418***	0.004	0.131	0.356**	0.482***	0.379**	0.689	2.026	5.450
	[0.213]	[0.164]	[0.278]	[0.162]	[0.134]	[0.153]	[0.163]	[0.133]	[0.175]			
Collaborator	−0.402	0.328	0.469	0.155	−0.045	0.040	0.253	0.073	0.153	7.710**	2.504	1.942
	[0.382]	[0.215]	[0.345]	[0.206]	[0.179]	[0.202]	[0.185]	[0.160]	[0.214]			
Outsourcer	0.407*	0.134	0.479	0.326*	0.097	0.048	0.235	0.083	−0.123	0.999	0.125	8.248**
	[0.219]	[0.189]	[0.310]	[0.179]	[0.145]	[0.178]	[0.196]	[0.163]	[0.219]			
Constant	−1.871***	−2.603***	−3.676***	−1.921***	−1.417***	−2.304***	−2.345***	−2.141***	−2.830***			
	[0.438]	[0.416]	[0.589]	[0.336]	[0.285]	[0.384]	[0.376]	[0.374]	[0.389]			
Observations	861			1158			1065					
Degrees of Freedom	41			42			42					
Wald Chi 2	293.39***			325.2***			346.63***					
log Likelihood	−752.2			−1065			−861.6					

Robust standard errors in brackets*** $p < 0.01$, ** $p < 0.05$, * $p < 0.2$

References

Alexy O, George G, Salter AJ (2013) Cui bono? The selective revealing of knowledge and its implications for innovative activity. Acad Manag Rev 38(2):270–291

Artz KW, Brush TH (2000) Asset specificity, uncertainty and relational norms: an examination of coordination costs in collaborative strategic alliances. J Econ Behav Organ 41:337–362

Benner MJ, Tushman ML (2015) Reflections on the 2013 decade award—"exploitation, exploration, and process management: the productivity dilemma revisited" ten years later. Acad Manag Rev 40(4):497–514

Blair R (2002) Policy tools theory and implementation networks: understanding state enterprise zone partnerships. J Public Adm Res Theory 12(2):161–190

Bodas Freitas IB, Castellacci F, Fontana R, Malerba F, Vezzulli A (2017) Sectors and the additionality effects of R&D tax credits: a cross-country microeconometric analysis. Res Policy 46(1):57–72

Bodas-Freitas IM, von Tunzelmann N (2008) Mapping public support for innovation: a comparison of policy alignment in the UK and France. Res Policy 37:1446–1464

Bressers HTA, O'Toole LJ Jr (1998) The selection of policy instruments: a network-based perspective. Journal of Public Policy 18(03):213–239

Brown SL, Eisenhardt KM (1997) The art of continuous change: linking complexity theory and time-paced evolution in relentlessly shifting organizations. Adm Sci Q 42(1):1–34

Camisón-Zornoza C, Lapiedra-Alcamí R, Segarra-Ciprés M, Boronat-Navarro M (2004) A meta-analysis of innovation and organizational size. Organ Stud 25(3):331–361

Cantner U, Joel K, Schmidt T (2011) The effects of knowledge management on innovative success–an empirical analysis of German firms. Res Policy 40(10):1453–1462

Cashore B, Vertinsky I (2000) Policy networks and firm behaviours: governance systems and firm reponses to external demands for sustainable forest management. Policy Sci 33(1):1–30

Cassiman B, Veugelers R (2006) In search of complementarity in the innovation strategy: Internal R&D and external knowledge acquisition. Manag Sci 52:68–82

Castellacci F (2008) Technological paradigms, regimes and trajectories: manufacturing and services industries in a new taxonomy of sectoral patterns of innovation. Res Policy 37:978–994

Cole A (2006) Decentralization in France: central steering, capacity building and identity construction. French Politics 4(1):31–57

Costantini V, Crespi F (2013) Public policies for a sustainable energy sector: regulation, diversity and fostering of innovation. J Evol Econ 23(2):401–429

Costantini V, Crespi F, Palma A (2017b) Characterizing the policy mix and its impact on eco-innovation: a patent analysis of energy-efficient technologies. Res Policy 46(4):799–819

Costantini V, Crespi F, Marin G, Paglialunga E (2017a) Eco-innovation, sustainable supply chains and environmental performances in the European Union industries. J Clean Prod 155:141–154

Costantini V, Crespi F, Paglialunga E, Sforna G (2019) System transition and structural change processes in the energy efficiency of residential sector: evidence from EU countries, structural change and economic dynamics, forthcoming

Costantini V, Crespi F, Martini C, Pennacchio L (2015) Demand-pull and technology-push public support for eco-innovation: the case of the biofuels sector. Res Policy 44(3):577–595

Crespy C, Heraud JA, Perry B (2007) Multi-level governance, regions and science in France: between competition and equality. Reg Stud 41(8):1069–1084

Czarnitzki D, Ebersberger B, Fier A (2007) The relationship between R&D collaboration, subsidies and R&D performance: empirical evidence from Finland and Germany. J Appl Econ 22:1347–1366

Damanpour F (1992) Organizational size and innovation. Organ Stud 13(3):375–402

Dechezleprêtre A, Glachant M (2014) Does foreign environmental policy influence domestic, innovation? Evidence from the Wind Industry, Environment and Resource Economics 58:391–413

Dechezleprêtre A, Neumayer E, Perkins R (2015) Environmental regulation and the cross-border diffusion of new technology: evidence from automobile patents. Res Policy 44:244–257

Dosi G, Lechevalier S, Secchi A (2010) Introduction: interfirm heterogeneity—nature, sources and consequences for industrial dynamics. Ind Corp Chang 19(6):1867–1890

Faems D, Janssens M, Madhok A, Looy BV (2008) Toward an integrative perspective on alliance governance: connecting contract design, trust dynamics, and contract application. Acad Manag J 51(6):1053–1078

Feldman MP, Kelley MR (2006) The ex ante assessment of knowledge spillovers: Government R&D policy, economic incentives and private firm behavior. Res Policy 35:1509–1521

Felin T, Zenger TR (2014) Closed or open innovation? Problem solving and the governance choice. Res Policy 43(5):914–925

Flanagan K, Uyarra E, Laranja M (2011) Reconceptualising the 'policy mix'for innovation. Res Policy 40(5): 702–713
Foray D, Llerena P (1996) Information structure and coordination in technology policy – a theoretical model and two case studies. J Evol Econ 6:157–173
Foray D, Mowery DC, Nelson RR (2012) Public R&D and social challenges: what lessons from mission R&D programs? Res Policy 41(10):1697–1702
Fredriksson G, Roth A, Tagliapietra S, Veugelers R (2018) Is the European automotive industry ready for the global electric vehicle revolution? Bruegel Policy Contribution, Issue n°26, http://bruegel.org/wp-content/uploads/2018/12/PC-26_2018_1.pdf
Furr NR, Snow DC (2014) Intergenerational hybrids: spillbacks, spillforwards, and adapting to technology discontinuities. Organ Sci 26(2):475–493
Grande E (2001) The erosion of state capacity and the European innovation policy dilemma a comparison of German and EU information technology policies. Res Policy 30:905–921
Greve HR (2007) Exploration and exploitation in product innovation. Ind Corp Chang 16:945–975
Gulati R, Nickerson JA (2008) Interorganizational trust. Governance Choice, and Exchange Performance, Organization Science 19:688–708
Gulati R, Singh H (1998) The architecture of cooperation: managing coordination costs and appropriation concerns in strategic alliances. Adm Sci Q 43(4):781–814
Gulati R, Wohlgezogen F, Zhelyazkov P (2012) The two facets of collaboration: cooperation and coordination in strategic alliances. Acad Manag Ann 6(1):531–583
Gupta AK, Smith KG, Shalley CE (2006) The interplay between exploration and exploitation. Acad Manag J 49(4):693–706
Hagedoorn J, Link AN, Vonortas NS (2000) Research partnerships. Res Policy 29:567–586
Hargadon A (2010) Technology policy and global warming: why new innovation models are needed. Res Policy 39(8):1024–1026
Hitt MA, Hoskisson RE, Hicheon K (1997) International diversification: effects on innovation and firm performance in product-diversified firms. Acad Manag J 40(4):767–798
Hoetker G, Mellewigt T (2009) Choice and performance of governance mechanisms: matching alliance governance to asset type. Strateg Manag J 30:1025–1044
Hoppmann J, Peters M, Schneider M, Hoffmann VH (2013) The two faces of market support—how deployment policies affect technological exploration and exploitation in the solar photovoltaic industry. Res Policy 42(4):989–1003
Howlett M (2009) Governance modes, policy regimes and operational plans: a multi-level nested model of policy instrument choice and policy design. Policy Sci 42(1):73–89
Howlett M (2019) Designing public policies: principles and instruments. Routledge, New York
Jensen MB, Johnson B, Lorenz E, Lundvall BA (2007) Forms of knowledge and modes of innovation. Res Policy 36:680–693
Jolly J (2018) Carmakers criticise 'unrealistic' EU plan to slash vehicle emissions. Gardian, 18 Dec 2018, retrieved January 2019. https://www.theguardian.com/business/2018/dec/18/carmakers-criticise-unrealistic-eu-plan-slash-vehicle-emissions
Kefferpütz R (2018) Car wars: the future of Europe's Car industry. Green European Journal 21 January 2018. Retrieved January 2019. https://www.greeneuropeanjournal.eu/car-wars-the-future-of-europes-car-industry/
Kuhlmann S (2001) Future governance of innovation policy in Europe— three scenarios. Res Policy 30:953–976
Laranja M, Uyarra E, Flanagan K (2008) Policies for science, technology and innovation: translating rationales into regional policies in a multi-level setting. Res Policy 37(5):823–835
Laredo P (1995) Structural effects of EC RT & D programmes. Scientometrics 34(3):473–487
Laursen K (2012) Keep searching and you'll find: what do we know about variety creation through firms' search activities for innovation? Ind Corp Chang 21(5):1181–1220
Levinthal DA, March JG (1993) The myopia of learning. Strateg Manag J 14(8):95–112
MacGarvie M (2006) Do firms learn from international trade? Rev Econ Stat 88(1):46–60
Magro E, Wilson JR (2013) Complex innovation policy systems: towards an evaluation mix. Res Policy 42(9): 1647–1656
Malerba F (1992) Learning by firms and incremental technical change. Econ J 102:845–859
March JG (1991) Exploration and exploitation in organizational learning. Organ Sci 2:71–87
Maskell P, Malmberg A (1999) Localised learning and industrial competitiveness. Cambridge Journal of Econonmics 23(2):167–185
Metcalfe JS (1994) Evolutionary economics and technology policy. Econ J 104(425):931–944

Metcalfe JS (1995) Technology systems and technology policy in an evolutionary framework. Camb J Econ 19(1):25–46
Metcalfe JS, Foster J, Ramlogan R (2006) Adaptive economic growth. Camb J Econ 30(1):7–32
Mowery DC, Nelson RR, Martin BR (2010) Technology policy and global warming: why new policy models are needed (or why putting new wine in old bottles won't work). Res Policy 39(8):1011–1023
Mustar P, Larédo P (2002) Innovation and research policy in France (1980–2000) or the disappearance of the Colbertist state. Res Policy 31(1):55–72
Nelson RR, Winter S (1982) An evolutionary theory of economic change. Harvard University Press, Cambridge
Nemet G (2009) Demand-pull, technology-push, and government-led incentives for non-incremental technical change. Res Policy 38:700–709
Neslen A (2016) EU parliament fails to close loopholes in controversial car emission tests. Guardian, 3 Feb 2016, retrieved January 2019. https://www.theguardian.com/environment/2016/feb/03/eu-parliament-gives-green-light-for-loopholes-in-car-emissions-tests
Nonaka I (1994) A dynamic theory of organizational knowledge creation. Organ Sci 5(1):14–47
OECD (1993) Public management developments, Survey 1993
OECD (2000a) Issues and developments in public management: survey 1996–1997 France. PUMA OECD
OECD (2000b) Public management developments in France: Update 1998. PUMA OECD
Pavitt K (1984) Sectoral patterns of technical change: towards a taxonomy and a theory. Res Policy 13:343–373
Peters BG (2000) Policy instruments and public management: bridging the gaps. J Public Adm Res Theory 10(1):35–47
Raisch S, Birkinshaw J, Probst G, Tushman ML (2009) Organizational ambidexterity: balancing exploitation and exploration for sustained performance. Organ Sci 20(4):685–695
Rantisi NM (2002) The local innovation system as a source of 'variety': openness and adaptability in New York City's Garment District. Reg Stud 36:587–602
Reichardt K, Rogge K (2016) How the policy mix impacts innovation: findings from company case studies on offshore wind in Germany. Environmental Innovation and Societal Transitions 18:62–81
Roy R, Sarkar MB (2016) Knowledge, firm boundaries, and innovation: mitigating the incumbent's curse during radical technological change. Strateg Manag J 37(5):835–854
Sabatier P (1986) Top-down and bottom-up approaches to implementation research. Journal of Public Policy 6:21–48
Salomon R, Shaver JM (2005) Learning by exporting: new insights from examining firm innovation. J Econ Manag Strateg 14(2):431–460
Schumpeter JA (1942) Capitalism, Socialism and Democracy, New York, Harper and Row
Song M, Van Der Bij H, Weggeman M (2005) Determinants of the level of knowledge application: a knowledge-based and information-processing perspective. J Prod Innov Manag 22(5):430–444
Stettner U, Lavie D (2014) Ambidexterity under scrutiny: exploration and exploitation via internal organization, alliances, and acquisitions. Strateg Manag J 35(13):1903–1929
Teubal M, Andersen E (2000) Enterprise restructuring and embeddedness: a policy and systems perspective. Ind Corp Chang 9(1):87–111
Tripsas M, Gavetti G (2000) Capabilities, Cognition and Inertia: Evidence from Digital Imaging. Strategic Management Journal 21:1147–1111
van de Vrande V, Vanhaverbeke W, Duysters G (2009) External technology sourcing: the effect of uncertainty on governance mode choice. J Bus Ventur 24:62–80
Veugelers R (2012) Which policy instruments to induce clean innovating? Res Policy 41(10):1770–1778
Veugelers R, Cassiman B (1999) Make and buy in innovation strategies: evidence from Belgian manufacturing firms. Res Policy 28:63–80
von Tunzelmann N (2009) Competencies vs. capabilities: a reassessment. Economia Politica – Journal of Analytical and Institutional Economics 3:435–464
Yang H, Zheng Y, Zhao X (2014) Exploration or exploitation? Small firms' alliance strategies with large firms. Strateg Manag J 35(1):146–157