Capturing the system-level effects of innovation policy: an assessment of publicly funded innovative entrepreneurship in Sweden

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Abstract

A new generation of innovation policies has placed renewed attention on understanding the innovation processes taking place on and affecting the system level. On one hand, there is a growing demand for policy instruments addressing the need for system change. On the other hand, there is still a lack of understanding of how innovation policy instruments contribute to a system-level impact. We address this gap by taking a programme perspective and proposing an analytical framework for assessing three types of effects: first-order, second-order, and system-level. Our approach is inspired by the functions of technological innovation system literature (TIS). We apply the analytical framework to the analysis of an innovative entrepreneurship instrument, the Swedish Innovation Agency VINNOVA's Innovative SME programme. We find that the public support programmes contributed significantly to SMEs' ability to influence system functions. Based on the findings, we argue that the analysis of innovation policy programmes should move beyond a narrow assessment of direct effects and consider more the second-order and system-level effects.

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1. Introduction

Two trends illustrate the current state of affairs in innovation policy studies. On one hand, the changing rationale of innovation policy towards addressing grand societal challenges (Schot and Steinmueller, 2018; Weber and Rohracher, 2012) has led to calls for more systemic innovation policy instruments (Janssen, 2019; Smits and Kuhlmann, 2004; Wieczorek and Hekkert, 2012). On the other hand, the rise of these systemic instruments for transformative change brings new challenges for policy analysis and evaluation (Grillitsch et al., 2019; Haddad and Bergek, 2020), calling for novel approaches for assessing the role and performance of individual instruments in the broader policy-mix. In particular, previous research has shown that an assessment of a policy programme should consider effects on different levels and of different types (Borrás and Laatsit, 2019; Dosso et al., 2018; Gök and Edler, 2012). Therefore, we need more comprehensive ways for assessing the merits of individual innovation policy instruments from a system perspective.

We argue that this requires an analytical framework that covers the three types of effects embedded in policy instruments: first-order, second-order and system-level effects. First-order effects are firm-level effects directly on the targeted firms while second-order effects are firm-level effects on third parties not targeted by the policy activity. System-level effects, however, are an effect on the system itself and its functions. Both first-order and second-order effects have been extensively studied and conceptualised (Hottenrott et al., 2017). However, the increasing interest in mission-oriented and transformative innovation policies has brought a renewed attention to studying systemic change induced by policy (Amanatidou et al., 2014; Arnold et al., 2018; Haddad et al., 2022; Janssen, 2019; Kao et al., 2019; van Mierlo et al., 2010; Warwick and Nolan, 2014).

Earlier studies have discussed assessing system-level effects, but mostly as produced by the whole policy-mix. Examples of this include 'systems of evaluations' (Arnold, 2004; Jordan et al., 2008) as well as 'meta-analyses' (Edler et al., 2008; Magro and Wilson, 2013), both combining different analyses for a systemic understanding. We argue that it is not always possible, nor necessary, to take a policy-mix perspective to analyse the system-level effects of innovation policy, as it can also be done on programme level. Therefore, we take a programme-centric view and demonstrate how system-level effects can be identified for an individual programme.

We propose a conceptual framework for capturing the first-order, second-order and system-level effects of a single policy instrument. We assess the approach through an analysis of the Swedish Innovation Agency VINNOVA’s Innovative SME programme. Our analysis includes a combination of quantitative and qualitative studies. First, we collected information and data for the population of 1341 SMEs supported through the programme between 2001 and 2015. A further cross-sectional study was conducted on a sample of 60 companies. The results demonstrate a clear link between VINNOVA support and the system's functions and functionality. We also found a solid relationship between the financial support a company received and the width of the number of affected functions. The findings strongly support the assumption that the funding contributes to the companies' ability to both develop and influence system functions.

The paper makes three important contributions. First, it demonstrates on a conceptual level how the three types of effects (first-order, second-order and system-level) can be combined to evaluate a policy programme. Second, it develops an analytical framework for assessing the system-level effects of a single programme, based on the functions of innovation systems. Third, it assesses the framework empirically using a novel dataset on Swedish SME support programmes.

We proceed as follows: first, we introduce the theoretical framework. Second, we provide an overview of the data and methodology. Third, we present the results and three case studies of Swedish companies. We conclude with a discussion on policy implications and further research perspectives.

2. Theoretical framework

In this section, we discuss the theoretical foundations of the study. We start with an overview of the systems perspective to innovation and then proceed to develop a corresponding analytical framework for assessing innovation policy.

2.1 Systems perspective to innovation

The systems perspective has been widely adopted within innovation policy over the last decades. It builds on the assumption that the preconditions for innovation and entrepreneurial activity can only be fully understood by considering the actions and activities performed by multiple actors embedded in an institutional context (Alvedalen and Boschma, 2017; Edquist, 1997; Stam, 2015). The system of innovation concept, originally developed by Freeman (1987) and Lundvall (1992, 1999) on the national level (NIS), has come to be applied to regional systems (RIS) as well as technological and sectoral regimes (Cooke et al., 1997; Malerba, 2002). Regardless of the type of system in focus, a systemic view on innovation and entrepreneurship entails a holistic approach to policy (Edquist, 2019) or at least an understanding of the interconnected nature of innovative and entrepreneurial activity.

In most definitions, the system of innovation includes a broad array of actors that perform activities contributing to system functions. Lundvall's definition of innovation system encompasses "…all parts and aspects of the economic structure and institutional set up affecting learning as well as searching and exploring…" (1992, p. 12). More specifically, an innovation system comprises three interrelated structural components: actors, networks and institutions (Carlsson and Stankiewicz, 1991). Actors can be grouped into three types: production structure (firms), knowledge infrastructure (universities, research institutes etc.) and support structure (policy makers and other actors tasked to support the actors, system and its functions) (Nilsson and Moodysson, 2015). These are linked together by network relationships and operate within an institutional setting (rules of the game) of formal and informal constraints and enablers.

Unlike the NIS and RIS approaches, the technological innovation systems (TIS) literature takes into account factors unique to a particular domain of knowledge. In the early development stages of the TIS concept, it became clear that although functions at the national level are significant, there are different dynamics within different technical areas (Carlsson et al., 2009). Carlsson and Stankiewicz (1991) define a technological innovation system as a network of agents that interact in a certain economic/industrial area with a certain institutional infrastructure (or set of infrastructures) and participate in the production, diffusion, and use of technology. In order to transform knowledge into economic activity, entrepreneurial activity (experimentation) is required.

In order to create a better understanding of the dynamics of technological innovation systems, the "functional dynamics" of TIS was developed. The functional dynamics is based on a system of central sub-processes in the larger process of innovation and diffusion (Bergek et al., 2008; Hekkert et al., 2007; Hekkert and Negro, 2009; Jacobsson and Bergek, 2004; Johnson and Jacobsson, 2001). These partial processes (or sub-functions, (Markard and Truffer, 2008)) include (Bergek et al., 2008):

• *Knowledge development and diffusion* (normally placed at the centre of a TIS)
• *Influence on the direction of search* (different competing technologies, applications, markets, business models, etc.)
• *Entrepreneurial experimentation*
• *Market formation* (actual market development and driving forces)
• *Legitimation* (social acceptance and compliance by relevant institutions is formed through conscious actions by various organizations and actors that can eventually help the system overcome its so-called "liability of newness")
• *Resource mobilization* (competence / human capital, financial capital and complementary assets such as complementary products, services, network infrastructure, etc.)
• *Development of positive externalities* (polished labour markets, specialized inputs and service providers, information flows and spill-over effects)

Bergek et al. (2008) claim that a TIS without lively experimentation will stagnate. Entry of new firms into the emerging TIS is central to the development of positive externalities. Hence, it is argued, new entrants may contribute to a process whereby the functional dynamics of the TIS are strengthened, benefiting other members of the TIS through the generation of positive externalities. This function is thus not independent but works through strengthening the other six functions of the TIS. It may, therefore, be seen as an indicator of the overall dynamics of the system. As we are aiming to analyse the wider effects of the Innovative SME policy instrument, we choose to focus on the entrepreneurial experimentation and its related externalities in the (technological) innovation system.

It should be noted that the word "entrepreneurial" refers not only to new or small businesses, but to the broader Schumpeterian concept of the ”entrepreneurial function" (i.e. new combinations of existing resources). This function can be filled by different types of actors, including large, established companies diversifying into the new technology (Bergek et al., 2008). A review of the existing literature on innovation systems shows that this, with the exception of technological innovation systems (such as Carlsson and Stankiewicz (1991)), usually does not include entrepreneurial individuals and activities created by new innovative firms. Lindholm Dahlstrand et al. (2019) argue that what has been particularly lacking is an analytical framework that, with reference to explicit mechanisms and processes around industrial dynamics at the micro level, articulates how acting entrepreneurs and entrepreneurship create effects on the entire system in the form of entrepreneurial experimentation for creation, selection and scaling up of new technology and innovations. They further argue that filling this gap in the literature requires (i) an understanding that entrepreneurial experimentation includes both "technical" and "market" experiments, and (ii) that entrepreneurship is analytically conceptualized in terms of its function in innovation systems (rather than being seen as a result of how the system works).

From a policy perspective, the functional view has a specific strength when it comes to understanding broader challenges for the system as a whole – often referred to as market and system failures or problems. Examples of systemic problems that derive from system failures include lack of resources within the system, fragmentation due to lack of interaction between actors, mismatch and incongruities of goals and strategies, and lock-in into established practices and technological pathways (Isaksen, 2001; Nilsson and Moodysson, 2015; Tödtling and Trippl, 2005). Others have classified system failures into infrastructural failures, network failures, capability and organizational failures, and adjustment failures (Howells and Edler, 2011).

In recent years and largely building on the innovation systems perspective, policy makers have increasingly started to focus on the existence and nature of system problems or failures. The logic is that a system perspective entails not only that different actors are interrelated and influenced by institutional conditions in the system, but also that policy influences the system as a whole and not only its components. This means that policy makers, as well as policy scholars, strive to address systemic problems and/or facilitate system change (Smits and Kuhlmann, 2004; Weber and Rohracher, 2012). For example, Wieczorek and Hekkert (2012) discuss that in order to address systemic problems, systemic instruments can be drawn along four basic types of problems related to the presence or capabilities of actors, institutional set-up, quality of the interactions and the quality of the infrastructure. Borras and Edquist (2013) add that the systemic design of instruments is dependent on the 'problem-oriented nature' of the design of instrument mixes.

2.2 Assessing innovation policy from a system perspective

The effects of policy programmes and instruments are notoriously difficult to assess. This is particularly the case with innovation system policy programmes that aim not only at direct firm-level effects but also system-level effects. It often happens that analyses of policy support to innovation and SMEs only reveal modest direct effects.

Innovative entrepreneurship, where the dual nature of innovative start-ups can be seen both as a distinct form of entrepreneurship and as a distinct mechanism for developing innovations (Audretsch et al., 2020), is a clear example where evaluations tend to focus primarily on short term economic effects in targeted firms, e.g. creation, survival and growth of new firms.

In those cases, and in defence of innovation policy, it is often argued that, while the direct first-order effects on the firms may be modest in short to medium periods, there are important effects in terms of for example spill-overs (second-order effects) and effects at the system-level that are rarely captured in output assessments.

There are however a number of difficulties in capturing these wider effects of innovation policy:

(1) second-order and system-level effects can rarely be isolated and measured quantitatively;

(2) the effects from spill-overs and system change are often realized in the (very) long run;

(3) such effects are mainly comprised of additionalities (e.g. behavioural additionality).

Based on this, policy actors are increasingly realising the need to capture a wider array of metrics to complement (not replace) existing outcome assessments of policy initiatives. By the nature of the second-order (e.g. spill-over) and system-level effects, this means more long-term perspectives, qualitative analysis of behavioural change, and a broader perspective in terms of who is affected (Autio et al., 2008; Georghiou and Roessner, 2000).

While system-level effects are under-conceptualized in innovation policy research, and as good as non-existent in entrepreneurship policy research, political science has a long tradition of studying so-called system-level effects. According to Jervis (1997, p. 6), a system perspective is relevant when (i) elements or units are interconnected in a way that changes in some elements or their relations lead to changes in other parts of the system, and (ii) the entire system exhibits characteristics, properties, and behaviours that are different from those of the system's parts. The latter points to an emphasis on emergence and emergent properties and away from methodological individualism.

Applying the logic of system-level effects to an innovation policy context, three levels of effects can be disentangled (see Figure 1):

- First-order effects on the actors directly targeted by or involved in policy activities. First-order effects are thus firm-level outputs and outcomes on the targeted firm that are the direct result of policy activity (Autio et al., 2008).For example, policy programmes that provide funding for research and development may contribute to the development or refinement of a new technology or product. Policy instruments encouraging entrepreneurship most often focus on reducing obstacles for new entrants, to enable firm survival and economic performance.

- Second-order effects, where a third party is impacted by the policy action. Second-order effects are thus firm-level effects on third parties – i.e. actors not directly targeted by the policy activity – resulting from for example spill-overs, diffusion and exchange (Autio et al., 2008). In the example above, this could mean effects on the focal firm's suppliers or customers, not directly targeted by the policy activity. The development of a new technology or product, for example, may infer increased sales or a build-up of new technological knowledge for suppliers and customers of the targeted firm through knowledge spill-overs.

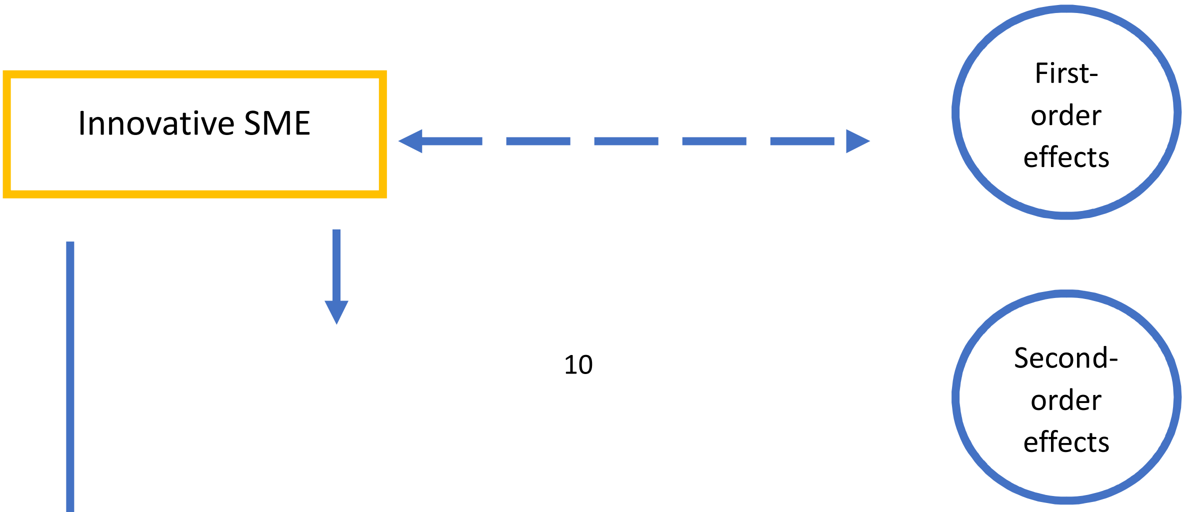
- System-level effects, where the effect (impact) is on the system functions rather than on any particular firm. For example, if a technology results in the emergence of a new industry or technological paradigm, changes might be necessary in the institutional landscape by influencing legislation or ways of doing business etc.

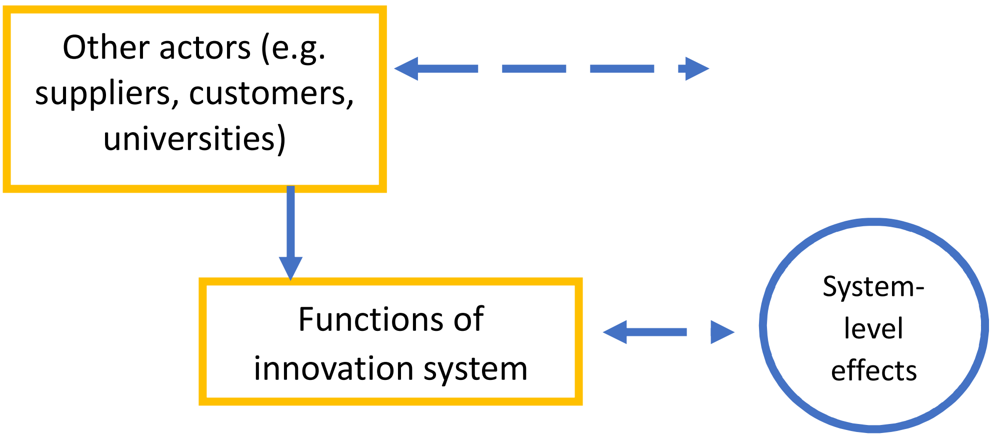
In the terms commonly used in the evaluation literature and following the definitions of OECD (OECD, 2002), first-order direct effects include both outputs and outcomes on the targeted firm. Second-order and system-level effects are associated with the term impact insofar as they are relatively more long-term and go beyond the targeted firm.

First-order direct effects can be measured directly and without much delay, and are thus (compared to second-order and system-level effects), relatively more easy to identify and evaluate in research and policy evaluations (even though no effect assessment is easy or unproblematic) (Autio et al., 2008). While more difficult to directly observe at the level of the targeted unit and further complicated, given that they emerge over longer time spans, second-order effects are in most cases also possible to isolate in impact assessments. Effects at the system level, however, are notoriously difficult to trace back to specific policies or action, partly because the effects are indirect, highly interrelated and influenced by a multitude of factors. System-level effects are characterized by nonlinear relationships and unintended/unanticipated outcomes, which makes isolating causal linkages difficult and prediction impossible (Jervis, 2012, 1997). The strict implication from this is that the difficulty of capturing system-level effects can frustrate any policy makers' attempts to understand and therefore design policy actions. At the same time, however, as the focus of innovation policy is increasingly on promoting system-wide transformation (Kuhlmann and Rip, 2018; Schot and Steinmueller, 2018) the need for an appropriate assessment framework is substantial.

Effects can be both positive and negative. Positive system-level effects are important motives for government efforts and also fundamental mechanisms for innovation and value creation in innovation systems. Negative system-level effects can be in the form of displacement effects linked to inputs and behaviours of different actors. In conjunction with major investments in R&D and innovation processes, these can, in practice, block the development of alternative development trails, and may then constitute an important system failure.

Figure 1: First-, second-order and system-level effects





Zooming in on the system-level effects, these can be further disentangled according to the functions of innovation systems. We believe that using the functions of innovation systems will provide a useful conceptual tool for the discussion on system-level effects since it allows for a more fine-grained analysis of these effects along with the specific functions. Our approach reflects a broader trend, where the structural analysis of systems of innovation and entrepreneurship has over the last decade given way to a focus on the functions performed by and within the system (Bergek et al., 2008; Hekkert et al., 2007). While the TIS-literature usually puts technological trajectories in the centre of the system, our focus is on entrepreneurial experimentation and spill-over effects created by new entrants. As argued above, this function is not independent but works through strengthening other functions of the TIS. Thus, rather than analysing one specific technological trajectory (including knowledge creation, diffusion and direction of search) we are interested in the role the entrepreneurial experimentation (mainly innovative SMEs) can play for the dynamics in a broad set of different technological innovation systems.[4] Thus, in this study, we focus on five system functions that are anchored in previous work on system functions (See Table 1).

Table 1: Functions of technological innovation systems (adapted from Bergek et al. 2008; Hekkert et al., 2007)

Innovation system function	Description	Examples of key effects

[4] The concept of motors of innovation (Suurs et al., 2010; Suurs and Hekkert, 2009) have also been used to describe the cumulative causation in the form of virtuous cycles, related to functions of innovation systems, in highly complex development processes.

Knowledge development, diffusion and direction of search	Creation of new knowledge and facilitation of information and knowledge exchange. Direction of search.	Scientific, technological, and market knowledge. Built and disseminated through R&D, learning from new applications, imitation etc.
Entrepreneurial experimentation	Creation, selection and scaling of new businesses	New businesses and new firms
Creation of new markets and business models	Identification and creation of markets or market niches as well as stimulation of the formation of local markets. This may include the attraction of new actors to the system as well as focusing existing system actors on relevant growth opportunities	Business opportunities identified and demand stimulated/created.
Regional labour market and resource mobilization	Building and attraction of resources (human, financial, complementary etc.) relevant to the RIS. Including creation of system infrastructure and exploitation of synergies within the system	Labour markets (skilled people); financial capital (e.g. venture capital); complementary assets (e.g. support services and products, input goods)
Legitimation and shaping institutions	Creation and building understanding, support and legitimacy for the activities and agendas (internally and externally). This includes actions to alter and affect formal and informal institutions	Internally: Strategic coherence, joint vision, shared understanding etc. Externally: Coherent image of the industry or agenda towards external actors.

The underlying assumption is that these functions are key conditions for innovation and entrepreneurship. Using these functions as the building blocks for a conceptual framework allows for an assessment of the system-level effects. This in turn completes the analytical approach based on three types of effects.

3. Evaluation of VINNOVA's Innovative SME programme

In this section, we will apply the analytical framework to the analysis of VINNOVA's Innovative SME programme. This programme can be characterized as an innovative entrepreneurship policy instrument. Despite allowing all kinds of SMEs to apply for innovation project financing the focus is primarily on entrepreneurial experimentation and relatively young innovative firms. This in turn, underlines the dual nature of the policy instrument, it aims to both encourage this distinct form of entrepreneurship and, at the same time, be a distinct mechanism for developing innovations. The Swedish government agency VINNOVA has, since its creation in 2001, financed a number of R&D programmes specifically aimed at SMEs and entrepreneurial firms. The most important of these are VINN NU, and Research & Grow.

The VINN NU programme was started in 2002 and targeted development-oriented start-ups to prepare and clarify business opportunities for innovative ideas in specific areas of competence. This included topics such as work-life development, biotechnology including medical technologies and food, energy technologies, information and communication technologies, materials, product development, process technology, services and IT use, and transport. Thus, this policy instrument cannot be considered an example of a policy aiming for transforming a specific technological trajectory, but rather encouraging increased entrepreneurial experimentation in a broad set of different technological innovation systems.

Similarly, the Research & Grow programme (launched in 2006) has a focus on strengthening SME's innovation capacity by increasing their access to new knowledge and new technologies for business renewal. Again, this is an example of a policy instrument with a clear intention to support an increased entrepreneurial experimentation in the system. The companies should be established with a strong ambition to develop further and grow. VINN NU and Research & Grow both ended in 2014. However, their input logics have been transferred to and further developed within the framework of a new collective VINNOVA programme, Innovation Projects in Companies, which was started in 2014.

Between 2002 and 2011, a total of 1309 companies applied for VINN NU funding, and, between 2006-2014, about 5200 companies applied for project financing in the Research & Grow programme. In 2014, the number of applications increased very sharply, a 65% increase compared to 2013. Compared to the Research & Grow programme, the number of applications for the new programme Innovation Projects in Companies increased by a further 36 per cent in 2015.

3.1 Earlier evaluations of direct effects

The effects of VINNOVA's funding of innovation projects in SMEs (the Research & Grow and VINN NU) have been analysed on some previous occasions. All earlier evaluations have analysed the resulting performance of the targeted SMEs (for example, survival, financing, growth in sales and employees), and few have included any other kind of (spill-over) effects. In other words, the majority of these evaluations are quite traditional and does not consider the dual nature of innovative entrepreneurship in any greater detail.

In 2008, Norrman and Klofsten (2009), concluded based on a survey of the participating companies that the objectives of the VINN NU programme had been met. A couple of years later, Bergman et al (2010) analysed the effects of Research & Grow and VINN NU regarding behavioural additionality. They concluded that companies showed many examples of additionality effects, with the clearest effects being that companies scaled up and accelerated their projects. In addition, clear differences were observed between Research & Grow and VINN NU programmes, where Research & Grow companies tended to change the direction of their R&D. Research & Grow financing enabled large SMEs to develop a completely new area, in parallel with the company's previous core business. The VINN NU funding led to a significant proportion of companies surviving the start-up phase. It was found that VINNOVA's financing tended to serve as a "quality marker", which affected companies' ability to attract additional (risk) capital (legitimacy). In addition, cumulative, mutually reinforcing effects proved to be common (Bergman et al., 2010).

In 2012, a control group analysis of companies was carried out in the VINN NU programme, which received funding during the years 2002-2010 (Samuelsson and Söderblom, 2012). The control group consisted of companies that applied for funding but were rejected in the last phase of the assessment process. The time horizon for analysis of the outcome variables was seven years, which was based on experience from previous studies indicating that the time horizon needs to be so long for some of the outcome variables. The analysis showed that the financed companies had significantly improved their capital growth, the number of employees and sales surpassing the control group companies, which "almost received" VINN NU financing. This difference was shown to grow over time, especially from five years after the funding.

Also, the national agency Growth Analysis carried out a control group-based evaluation of the VINN NU and Research & Grow programmes (Tillväxtanalys, 2014). The analysis covered companies that had been financed in either of the two programmes between 2002 and 2010. The study could find no statistically reliable difference in the number of employees, value-added per employee, or the proportion of highly skilled employees for the VINNOVA-funded companies. Growth Analysis concluded that none of the programmes had had an impact on the variables studied and recommended that the programme's target formulations be tightened up and that more evaluations of this type be carried out.

In 2013 VINNOVA itself analysed the effects of funded Research & Grow projects 3 to 5 years after the end of the projects (VINNOVA, 2014). One conclusion was that this timeframe was too short to draw conclusions on the magnitude of the revenue and employment effects. Based on conservative estimates, the analysis pointed to the fact that the intangible assets and innovations generated in R&D projects within the Research & Grow programme in turn delivered economic value that overall exceeded the direct costs of the projects. In addition, it was found that the innovations generated in enterprises were most often developed in very non-linear and complex patterns after the VINNOVA project. A methodological conclusion was that a longitudinal analysis of funded projects and companies needs to be a central part in future evaluations.

The first step in this direction was taken in VINNOVA's impact analysis in 2016 (VINNOVA, 2016). Using a triangulation approach (VINNOVA, 2015) this study included: (a) corporate and group dynamics analysis based on register data; b) a survey of companies that had received Research & Grow funding; c) a patent survey; d) personal interviews with a selection of companies and e) openly published data on the further development of intangible assets. The analysis showed that the Research & Grow programme made a significant contribution to the implementation of R&D projects that would not have been implemented without VINNOVA's funding. The results showed direct economic values of just under SEK 2 billion from the innovation processes resulting from the Research & Grow projects. Value creation was found to be severely skewed, with 10 per cent of innovation processes accounting for 85 per cent of the value creation, which is typical for portfolios of innovation projects.

To some extent, there is an overlap between the impact study of 2016 and the present study. The sample in this study (see section 3.2) is based on the selection and results from VINNOVA (2016) and the analysis can be seen as a step forward towards a longitudinal analysis of funded companies, their collaborative partners and the systems they operate in.

3.2 Data and methodological approaches

While few of the earlier evaluations of VINNOVA's Innovative SME instruments included any broader discussions or analysis of the dual nature of innovative entrepreneurship, the focus of the present study is to analyse both direct first-order effects in the targeted SMEs, and also second-order effects influencing collaborative partners and the system functions. While entrepreneurial experimentation and innovative entrepreneurship is considered to play a particularly important role for economic development, technological advancement and societal impact (Audretsch et al., 2020) its role has often been neglected in earlier research (Fini et al., 2018; Janssen, 2019; Markman et al., 2019). Thus, for this purpose, the analytical framework described in section 2 was tested in an analysis of VINNOVA's SME programme.

This analysis includes a combination of quantitative and qualitative studies:

a) an overall mapping and quantitative analysis of the 1341 SME companies supported through VINNOVA's SME programme (between 2001 and 2015),
b) a cross-sectional analysis of a smaller population of 88 SMEs (including companies that have received both a targeted SME support and consortium-based support), where these quantitative data were combined with qualitative information through interviews with directly involved SMEs[5],
c) case studies of twelve SMEs, including questions on both direct first-order, second-order, and system-level effects.

The overall mapping includes data, collected by VINNOVA, for all 1341 SMEs that were financed between 2001 and 2015[6]. For part b) of this study, 88 companies that answered VINNOVA's questionnaire from the 2016 effect study (VINNOVA 2016, see above), were selected to be interviewed by telephone[7]. The final sample for the cross-sectional study

[5] The sample for the cross-sectional analysis consists of companies that have received both a targeted SME support (1341 SMEs) and a consortium-based support (737 SMEs). The total population of SMEs that received support from both these programs amounts to a total of 199 companies. Several of these SMEs have received support for more than one project in VINNOVA's SME program. Only SMEs participating in the VINNOVA 2016 survey were selected for the cross-sectional study, thus leaving a final sample of 88 SMEs.
[6] This mapping includes data on participating SMEs with regard to: industry classification, size of participating companies and potential group affiliation, age at first participation, financial data, bankruptcies, mergers and liquidations, Swedish/foreign ownership (2015), number of projects & total project financing.
[7] Publicly available information (based on e.g. Annual reports, media coverage, web sites etc.) was collected for all firms. In addition also all information collected by VINNOVA was made available. This included, for example, the applications for funding, the project reports, patent data statistics, as well as all data collected in the broader mapping of the 1341 SMEs and the survey from 2016. In addition, 59 of these 88 SMEs had been interviewed earlier in 2014/15 (VINNOVA 2016), and transcripts from these interviews were made available to the authors.

consists of 60 SMEs who answered our questions in a telephone interview[8]. All phone interviews had been completed in the fall/winter 2016/17 and took between 30 minutes and two hours[9]. The differences are largely explained by the complexity of the various companies' innovation processes We experience that with 60 phone interviews (response rate 68%) we achieved saturation[10].

In part c), experts at VINNOVA helped to identify a group of companies that were deemed likely to be particularly interesting for case studies. In this group, 16 companies have been identified as having a particularly large potential system impact. All have been contacted, and twelve of these companies agreed to participate in the study. In all of these 12 cases, at least one personal interview has been conducted during the autumn/winter of 2016/17. Eleven of these interviews were conducted in face-to-face meetings and lasted an average of about 1.5 to 3 hours, one interview was conducted by telephone due to the respondent's availability (residence in the USA). All interviews have been recorded as case histories. In a follow-up study in 2018/19, 30 of the SMEs' collaborative partners were interviewed[11]. Collaborative partners interviewed included both commercial partners (for example customers and suppliers) and research partners (for example commercial firms but also universities and public institutes). Thus, the number of interviews in the case studies differs from case to case, from a minimum of two up to the maximum of seven.

[8] Four of these 88 companies have disappeared from the population due to bankruptcy, and another 24 have been impossible to get in contact with or opted to refrain from participation.

[9] All interviews were made by two of the authors together with a colleague, Professor Diamanto Politis. We gratefully acknowledge her work interviewing 15 of the SMEs. The interviews were all guided by a set of similar questions (see Appendix) but undertaken as a very open discussion. All the interviewers are experienced researchers each with over 20 years experience of performing open interviews. The coding of answers was made jointly by the three interviewers.

[10] A response-bias analysis has been made using chi-2 and t-tests on a number of variables that are important to consider to see if the sample (60 SMEs) is representative for the population (199 SMEs). This analysis points to a number of areas where there are significant differences between the groups: sectorial composition, group affiliations, exports and number of financed innovation projects. There were however no significant differences in company age, net sales, employment, or total amount granted from VINNOVA.

[11] In total, 40 collaborative partners were identified for the 12 cases. 30 of these were interviewed in personal interviews. The interviews lasted between 20-80 minutes. The authors gratefully acknowledge the help from Bachir Brahim who assisted interviewing collaborative partners.

Both the telephone interviews in part b) and the personal interviews in the cases (part c) used a similar set of guiding questions about the three types of impact and effects (see Figure 1 and the Appendix[12]):

(1) First-order effects (direct impact of projects on the company)

(2) Second-order effects (impact of projects and company on other actors)

(3) Effects on the functions of the system (impact of projects and companies on the system, as well as the impact of other (interoperability) actors on the system)

3.3 Results: The cross-sectional study

The results of the cross-sectional survey are based on secondary information (publicly available or collected by VINNOVA, part a and b of the study, see footnotes 2 and 3 xx above) and personal telephone interviews with 60 SMEs that had had two kinds of government (VINNOVA) support: both SME-support and consortium-based support (i.e. not specifically designed for SMEs).

Overall, this group of firms are primarily active in sectors like business services, manufacturing, information and communication, as well as research and development. There are very few SMEs outside these sectors that have received any support from VINNOVA (no matter if it is SME-support or consortium-based support)

As can be seen in Table 2, the SMEs in the cross-sectional survey are mainly young start-up firms, they employ on average 25 persons (ranging from 0 to 265), have sales of between 2 MSEK to 700 MSEK (average 48 MSEK), and have got several projects accepted for VINNOVA -funding (between 2 and twelve projects, average 4,5). Some are profitable, while others are not. These SMEs show a very high patenting rate, as many as 79% of the SMEs have been awarded patents. Two other striking features are that, first, as many as 60% of these SMEs have a university origin. This figure is very high if compared with the 5 % of all newly started

[12] The questions were used as a guidance and all interviews were performed in an open manner, allowing both the interviewer and the interviewee to elaborate upon specifically interesting topics and issues. As mentioned, coding of the answers in the interviews was made jointly by the interviewers.

firms in Sweden (Andersson et al., 2015). The second striking aspect is that as many as 14% of these SMEs have been acquired, already at this early stage in their life.

Table 2: SME characteristics – cross-sectional study (figures from 2016)

	Min	Max	Mean
Start year	1961	2011	2000
Sales (kSEK)	2.2	721 761	47 661
Employees	0	265	25
Profit (kSEK)	-21 015	36 192	-1 285
# financed projects	2	12	4.5
Tot financing (kSEK)	555	34 703	5 807
Patents			79%
University origin			60%
Acquired			14%

Considering that 60% of the SMEs have a university origin, it is perhaps not surprising to find that Universities are considered the most important collaboration partner for 55% of the SMEs. Almost as many, 48%, report customers being among their most important collaboration partners. Having collaboration with the public sector (18% of SMEs) is especially important for firms in the life-science sector.

Looking at the direct effects for innovative SMEs receiving government support from VINNOVA, we find that this support has resulted most frequently in a new product or prototype. In addition, the majority (53%) of the SMEs have been awarded a patent as a result of the support. Other significant effects are gaining product knowledge and enabling market introduction of new products and services. The latter is often a challenge for university-based SMEs.

Data from Annual Reports were used to measure employment and sales growth. Based on this, we find the direct effects in terms of employment and sales to be relatively modest (Table 3). Only a few of the supported SMEs report medium to high effects on their increased sales (22%) or employment (17%). At least 30% of the SMEs could see no effect at all on sales and employment. Instead, based on answers in the interviews, the supported SMEs consider themselves to have contributed with second-order spill-over effects that have created both growth and employment increase for their partners. In general, customers were considered partners that have benefitted most, and this is where the SMEs see the most important spill-overs in terms of growth. In addition, these effects are expected to continue in the future, so far, the majority of the SMEs can report second-order effects, but 70% of them expect that they will see further effects in the future.

The very complex and important question about the effects on the functions of the system has been analysed in terms of the supported SMEs view of their own contribution to the functions of *Knowledge development/direction of search, Regional labour market and resource mobilisation, Entrepreneurial experimentation, Creation of new markets and business models, Legitimacy / institutional framework*.

There is a large variation in the answers, although in most cases (2/3 of the SMEs) this group of SMEs has a frequent and strong influence on the system's *knowledge development and the direction of research*. It is also common (55% of companies) that the SMEs have had an impact on *market formation*. For some SMEs, it has simply been necessary to try to create new markets, as these have not previously existed. It is also pointed out in some cases that the latter has been the company's greatest challenge because this kind of market formation is both expensive and can take a long time (often referred to as the ‘valley of death’). It is primarily due to the development of new business models that this function has a strong system impact.

The companies also have a strong impact on *entrepreneurial experimentation*. Many of the SMEs (25%) have themselves spun off additional new firms or have had employees leaving to create their own new companies. These new spin-offs also affect the system's function. Another common type of impact on the system's entrepreneurial experimentation is that these SMEs are often identified as "precursors" or role models. For example, several of the interviewed companies state that they actively participate in various entrepreneurial activities and programmes linked to, for example, different regional activities or universities.

Table 3: First-order, second-order, and system-level effects

First-order effects in target SME: *(share of SMEs, %)*	***Employment growth***	***Sales growth***
None	31,7	30,0
Low	51,7	48,3
Medium	11,7	15,0
High	5	6,7
Total	100	100

Second-order effects on collaborating partners	*Share of SMEs (%)*
Effects on intellectual property	12
Effects on sales	53
Effects on employment	23

System-level effects	Share of SMEs (%)
Knowledge development/direction of search	68
Regional labour- market and resources	50
Entrepreneurial experimentation	52
Creation of new markets and business models	55
Legitimacy/Institutional	20

The arguably most striking example of role models that affect entrepreneurial experimentation as well as legitimacy is acquisitions. One of the companies noted from their own experience that: "If you are paid one billion SEK in an acquisition, it is clear that there are many others who are interested in making the same journey." It is clear that the acquired companies affect many others wanting to start new businesses.

Resource mobilisation, which includes both financial capital, skills and human capital, is to a large extent a regional function. It should be noted that the 50% figure would most likely have been higher if the SMEs in Stockholm (the Swedish capital) had been excluded. In the Stockholm region, companies do not experience the regional importance of the system to the same extent as SMEs do in other Swedish regions.

Finally, it can be noted that about a fifth of the SMEs has had an impact on the *institutional framework*. This is especially prominent among companies within either environment-related or biotechnology / drug-related products. It is also clear that this system function takes longer to materialise and to create an effect.

Although there are a number of companies in the population (four) who do not report any system impact at all, the majority of companies have affected more than one of the system's functions. A total of five companies (8%) claim to have had an effect on all analysed system functions.

There is a clear link between VINNOVA's support and overall system-level effects. A higher amount of financing from VINNOVA resulted in wider system-level effects, that is, impact on a higher number of functions. Similarly, receiving several VINNOVA-funded projects resulted in wider effects on the system functions[13]. There is clearly a connection between VINNOVA 's financial support and the companies' ability to influence the system's functioning.

3.4 Case studies

In the course of the study, 12 case studies were conducted. We present here three cases that illustrate particularly well the need for capturing the three types of effects when assessing an innovation policy programme, in particular system-level effects.

3.4.1 Case 1 – IT company

One example is the case of a **small information technology firm** in northern Sweden. The firm received funding for two VINNOVA projects (2003 and 2013), both focused on the development of new information and communication technology. While both projects centred on geographical positioning technologies, the market applications of the technology were vastly different. The first project aimed to develop a traffic positioning system in collaboration with, amongst others, the Swedish Transport Administration. Even though the project was described as a success, it never led to any commercial breakthrough for the company. It did however contribute to scaling up the firm’s competence within this area and the subsequent identification of another related area for the commercial application of positioning technology. Located in a mining region in northern Sweden, the idea emerged to adapt the technology for underground purposes. The 2013 project thus focused on adapting the technology to develop an entirely new positioning and intelligence technology for underground purposes, mainly in the mining industry.

Following the move into mining intelligence in conjunction with the second VINNOVA project in 2013, the company experienced 800% growth over a five-year period. The system is now used by a number of large international mining companies in Europe, Australia, as well as North and South America. In 2017 a global world-leading company that manufactures industrial tools and equipment acquired 1/3 of the firm. Even though it was 10 years between

[13] The relationship between the financial support and the overall impact on the system's functions is highly correlated and significant (Pearson correlation 0.36 p <0.005). Similarly for the relationship between the number of projects financed by VINNOVA and the overall system impact (Pearson correlation 0.43 p <0.001).

the two projects and they addressed different markets, the technological domain of positioning systems were similar.

The importance of long-term innovation policy funding schemes is made quite clear in this example. Firstly, whilst the first project (2003) was a commercial failure in the sense that the resulting product did not achieve sufficient market penetration, the competencies developed through the project contributed to new applications within the mining industry. Secondly, the second project (2013) was crucial for the firm as it came at a time when other funding options were limited. The fact that the company had failed to develop a commercially successful product in the early 2000s despite a total of SEK 80 million in public and private funding and venture capital made it difficult to attract new venture funding. Thus, the VINNOVA project provided essential funding, albeit small-scale (in total approximately SEK 2.5 million), that was needed in order to adapt and market test the technology and product. Furthermore, the fact that the second project was carried out in collaboration with a large Swedish mining company greatly shortened the distance to market.

The case illustrates effects on all three types of effects: direct, second-order, and system-level effects. In terms of direct effects, the firm experienced a high growth rate in terms of sales and employees. While vastly larger than the relatively small VINNOVA support, the direct effects are not the most significant from a policy perspective. The second-order effects identified by the respondents are significantly greater. To illustrate this, one of their larger customers, a global mining company, estimate that the new mining intelligence solution led to a 20% increase in productivity in their mines (due to shorter downtime etc.) plus large annual savings as a result of optimization of, for example, ventilation systems etc. Other second-order effects are found with the firm's suppliers and the global company that acquired 1/3 of the firm. At the system level, the effects are currently modest, though potentially substantial. A notable system-level effect discussed by the respondent has to do with increased safety and security as a result of the new technology. They, therefore, foresee that safety regulations, initially at least in Sweden, will be increased as a response to this new technological development.

Another aspect that is evident in this case has to do with temporality and interconnectedness. The initial project enabled the development of the basic technology and product whilst the second project enabled the adaption of the underlying technology to a new market and platform. In particular, the second project greatly helped the fast development, proof-of-concept and consequently initial customer acquisition. The direct effects arose early on, close to the time of the project. In later stages the second-order effects affecting their suppliers (knowledge build-up, increased orders, additional employment and growth) and customers (production optimisation, savings, better safety etc.). At the time the study was conducted, the second-order effects started to take hold. The potential system-level effects were yet to be actualized.

3.4.2 Case 2 – Healthcare start-up

Other firms showed different patterns of direct first-order, second-order and system-level effects. One example is a **start-up that received funding for projects involving a diagnostics platform for healthcare providers**. The aim was to develop better e-platforms for diagnostics and the organisation of complex healthcare services. The funding was in this case, in contrast to the first example, substantial (two projects combined received approximately SEK 29 million) and organised as large consortia projects. In spite of the large-scale funding, the direct effects of the project were modest. The start-up, which originated as a corporate spin-off, had difficulties achieving market penetration and scaling up and eventually ended up being acquired by a Swedish company within the same industry. From the perspective of the SME and founder, the project failed to reach its full potential. Despite this, the claimed system-wide effects are substantial. The technological platform for diagnostics that was developed has led to an improvement in how public health organisations arrange their diagnostics administration process. The effects of the projects are thus expected to be greater at the system level within public healthcare. Furthermore, the acquiring firm experienced positive second-order effects in terms of new product development and skill upgrading. At the time of the study, the diagnostics platform was used to improve diagnostics and healthcare organisational efficiency in several Swedish regions, as well as in hospitals in France and Holland.

3.4.3 Case 3 – Weaving technology start-up

The two examples above illustrate system-level effects in terms of societal rather than financial/business effects. In other cases, the system-level effects are manifested mainly in terms of the transformation of industries and competition. One such example is **a start-up that develops new technologies for the weaving industry**. The technology developed and tested in the context of the VINNOVA projects has the potential to revolutionize the weaving industry globally as it affects the industry's ways of production. A patented weaving technique called Instant Thread Colouring (ITC) makes it possible for embroiders and weavers to dye the yard/threads during the weaving process based on inkjet technology. The project firm has been involved in six smaller VINNOVA-funded projects, mainly to develop and refine technologies, over a nine-year period, receiving approximately SEK 6 million in total. Four of these projects aimed specifically at the ITC technology in terms of: i) demand/market-analysis of ITC technology in the industrial (non-consumer) sector; (ii) test and assessment of dying technology, test of components and functions; (iii) optimization of liquids (dyes) for thread colouring; and (iv) a feasibility study to verify the technological, practical as well as economic viability of the ITC unit.

The technology has the potential to disrupt the global weaving industry, as it would enable manufacturers to dramatically reduce stock and re-set times by avoiding re-threading machinery with a vast number of pre-coloured threads (up to 100 threads per machine). This would vastly reduce the demand for low-skilled (low-cost) labour, making obsolete many current weaving plants and potentially changing the locational distribution of production sites in the industry which are currently largely driven by labour costs.

At the time of the study, the company had recently (2016) market-launched the technology and received much attention from the weaving industry. While the system-level effects in terms of reducing labour-intensity of the industry and its global value chain were potentially dramatic, it is yet to be realised. Furthermore, with the inclusion of inkjet technology, the boundaries between industries are blurred. To illustrate this, in 2018 the firm, under a new name, entered a strategic partnership with the printing giant Ricoh "to revolutionise the textile industry with thread colouring innovation". Since then, the company has continued to grow and attract venture capital, as well as received the premier national award for innovation in Sweden (SKAPA award).

3.5 Discussion on VINNOVA's Innovative SME programmes

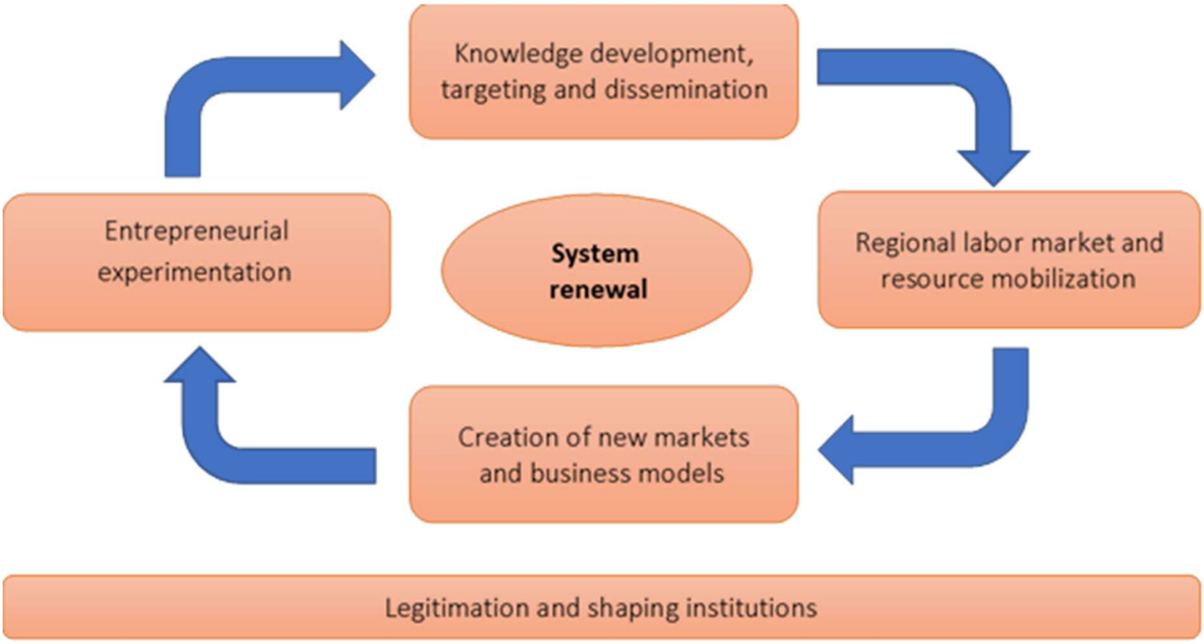
The study placed a particular emphasis on the temporality and interconnectedness of direct, second-order, and system-level effects. As expected, it emerges from the respondents' accounts that there are substantial time-lags between direct and system-level effects. The examples discussed above mainly illustrate system-level effects that, whilst not fully realised, are starting to impact system structures, networks and institutions, be it global production networks, national formalised institutions (laws and regulations) or ways of organising public healthcare systems. These represent some of the most promising system-level effects identified in the 12 case studies. Other examples include innovative technology for PVD surface treatment for the weight reduction of fuel cells in vehicles, life science start-ups involved in protein biomarker technology for precision medicine and new solutions for holographic microscopy.

Several of the SMEs identified concrete and potentially substantial system-level effects in the form of new market creation, stimulation of entrepreneurship, and institutional change. Many of these were, however, only partially realised at the time of the study, illustrating the extremely long time span of system-level effects of policy. Furthermore, the temporality of effects differed between projects, industries and firms but also between different types of effects. Despite the long time spans and high degree of uncertainty, impact assessments of policy programmes should not exclude system-level effects as their potential may be substantial both at the level of the industry and country. In line with Jervis' (1997) view, it is important to consider system-level effects in designing innovation and entrepreneurship policy. Especially as policy actors increasingly place transformation as one of their primary goals.

Acknowledging the interconnectedness of system-level effects thus goes in line with the systemic view of innovation. Drawing inspiration from the effects identified in this study, several examples can be drawn upon to illustrate the interconnectedness of effects. Two types of system-level effects were most often identified by the respondents: *strengthening of local labour markets* and *creation and diffusion of knowledge*. Labour market upgrading and knowledge generation and diffusion effects are in many cases first-tier effects (i.e. the project aims to create knowledge and/or directly results in increased demand for inputs and labour). These effects go hand in hand in the sense that upgrading the skills and knowledge in and across companies leads to strengthening the skill level within the local labour market. As new knowledge is created, upgraded and diffused within and between regions and industries, the potential for entrepreneurial experimentation increases. Both in terms of higher levels of specialised knowledge leading to incremental improvements in existing technology and processes, and in terms of linking unrelated knowledge bases with the potential to lead to radical new solutions. Such processes of entrepreneurial experimentation, in turn, contribute to the formation of new markets and business models. Additionally, the processes of upgrading knowledge and strengthening labour markets also contribute to legitimising new avenues for business development.

Such interconnectedness infers that system-level and second-order effects should be seen from a longitudinal perspective where different effects arise at different points in time and where some types of system-level effects precede others. Furthermore, the interconnectedness is not one-directional. Effects may be mutually reinforcing; for example, where strengthening human capital in terms of skills and competencies within a sector and/or region leads to competence development and diffusion, for example, increased absorptive capacity. This, in turn, has the potential to generate system-level effects in the form of identification of new (market or technological) opportunities which can improve the conditions for entrepreneurship and experimentation. An advantage of considering the interrelated nature of different types of effects is that it illustrates the potential for so-called 'virtuous circle'. With the creation of better conditions for entrepreneurial experimentation within a system, this can lead to further reinforcement of resources and generation and diffusion of knowledge. Figure 2 exemplifies the interconnectedness of system-level effects.

Figure 2: Interconnectedness of system-level effects in an innovation system



These types of effects are difficult to isolate and measure in quantitative output studies. Tracing system-level effects typically requires in-depth analysis where the **interconnectedness** and temporality of both realised and potential effects are identified and valued. Importantly, while system-level effects, especially when they build upon each other, may be highly important for an experimentally organised economy, they should not be used as an immediate justification of any policy programme.

It should be stressed that the second-order and system-level effects are not necessarily positive (see also Fini et al. 2018). By inverting the logic above, a vicious circle can also be delineated. One in which weak human capital within a sector or region can be expected to a have negative impact on knowledge creation and diffusion which in turn has an adverse effect on the preconditions for entrepreneurial experimentation. This is sometimes discussed in terms of negative lock-in and path dependency within regions. Growth and development patterns are heavily dependent on the historical industrial structure within a sector, region or country (Neffke et al., 2011). For renewal and transformation to take place, an ability to develop and absorb new knowledge is required. A system perspective on innovation and entrepreneurship policy emphasises the importance of a well-functioning whole (system) where all of the system functions develop iteratively and often over long time periods.

The weaving technology case above is an example of potential negative system-level effects. The technology has the potential to disrupt the industry in ways that increase profits and lower the consumer price of products, but at the same time, it may lead to layoffs and unemployment in what is currently a labour-intensive sector in many developing countries.

4. Conclusions

This paper sets out to explore a new approach for evaluating innovation policy instruments in response to the calls for more systemic evaluation frameworks. We have specifically applied this approach by exploring how entrepreneurial experimentation can generate system wide effects. The dual nature of innovative entrepreneurship, where innovative start-ups can be seen both as a distinct form of entrepreneurship and as a distinct mechanism for developing innovations (Audretsch et al. 2020), is a clear example where earlier evaluations tend to focus primarily on short term economic effects of targeted firms, for example, creation, survival and growth of new firms. Here we have instead focused on entrepreneurial experimentation and second-order effects created by new entrants in a technological innovation system. Entrepreneurial experimentation, in the form of innovative start-ups, is not an independent function, but works through strengthening other functions of the TIS. Thus, rather than analysing one specific technological trajectory we suggest that entrepreneurial experimentation (mainly innovative SMEs) can play an important role for the dynamics in a broad set of different technological innovation systems.

We have suggested an approach that combines three types of effects – first-order direct effects, second-order effects and system-level effects. Combining the three allows for a comprehensive assessment of the merits of a programme by acknowledging the multiple types of effects a policy instrument can have.

Our point of departure lies in the realisation that previous research on innovative entrepreneurship and associated innovation policy programmes has mainly focused on direct first-order effects on targeted firms, while the second-order and system-level effects have received little attention. This is particularly problematic given the growing emphasis on transformative and holistic innovation policy, and its corresponding attention to systemic instruments. We addressed this gap by looking at the effects on all three levels for a particular programme. To assess the merits of an innovation policy programme, all three levels need to be combined. While all three are necessary, none of them is sufficient on their own. For example, even if an analysis of direct effects can reveal no particular benefits from a programme, the same programme can have important second-order or system effects. Therefore, a comprehensive evaluation approach would include all three levels.

We addressed the issue in a novel way by taking a programme-centric view instead of a policy-mix perspective. Previous studies have indeed acknowledged the need to look at system-level effects, but mostly as produced by the whole policy-mix and not by individual programmes. We aimed at demonstrating how the effects on all three levels can be identified for a single innovation policy programme. A particular hurdle in doing this was the lack of proper conceptual frameworks for assessing the system-level effects from an innovative entrepreneurship programme's perspective. In order to do that we used the functions of technological innovation system approach, allowing for a programme-centric assessment of the three different types of effect.

We tested the framework empirically through its application on VINNOVA's Innovative SME programme. This was based on data gathered through a combination of quantitative and qualitative studies on the SMEs that had been supported in the period of 2001-2015. Our findings showed significant second-order spill-over effects between SMEs and their collaboration partners. In addition, there was a clear connection between public support and impact on system-level functions.

Importantly, for a majority of companies, different innovation projects are strongly interconnected, based on each other and it can be difficult to derive an individual effect for a specific project. Therefore, publicly funded support for innovative SMEs cannot be guided solely by portfolio thinking with a focus on direct effects. Instead, the cumulative and non-linear innovation processes must be considered in the policy goal setting of instruments, requiring a broader view that includes second-order and system-level effects.

The cases covered by the analysis illustrated the significance of incorporating system-level effects in impact assessments and the challenges associated with doing so. On the one hand, the cases show several substantial effects on the system level. On the other hand, these effects are to a large extent still at an early phase and thus potential rather than realised. The analysis points to a temporal difference between direct effects that are realised over a relatively short time span, second-order effects that are realised in the short to middle term, and system-level effects that are often realised in the long to very long term. A key implication of this is that policy with transformative ambitions needs to adopt an experimental design and be open to very long-term impact assessment. To add to the high level of complexity, our findings also provide several examples of how multiple projects funded over time lead to commercial success as well as potential system effects. However, it is crucial that these cases are not used to justify ‘throwing good money after bad’, but rather a call to carefully assess potential multiplier effects of additional funding.

All in all, the paper carries a three-fold relevance for policy. First, it suggests a novel analytical framework for capturing the system-level effects of individual innovation policy programmes through the system functions. Second, it tests this framework in the real-life case of the VINNOVA Innovative SME programme in Sweden. The analysis of the case reveals that the analytical framework is capable of demonstrating the extent to which public funding contributes to entrepreneurial companies’ ability to influence the system functions. Third, the study influences our understanding of policy goal setting. Support to innovative SMEs is often evaluated in terms of direct effects on SME growth, yet we have demonstrated that system effects are as important in policy assessment and planning. Earlier assessments of the same (innovative entrepreneurship) policy instruments (Tillväxtanalys, 2014) concluded that none of the programmes had had an impact on the variables studied and recommended that the programmes’ target formulations be tightened up. We suggest that the dual nature of innovative entrepreneurship, including system wide effects, should also be part of such target formulation and evaluations. The study presented here can be seen as a first application and trial of the framework. The long timespans needed for system-level effects to materialise underlines the importance of using (very) long time frames when analysing system change resulting from policy instruments and interaction. We would suggest further longitudinal studies and research to address and analyse long term system renewal resulting from policy interaction. Such analysis should include changes over time, between industries, and regions, as well as the effects of increased policy learning and policy experimentation.

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Appendix 1. Interview guide used in telephone interviews

Introductory questions about VINNOVA projects and technology:

1. How do you describe your role in the (technology) field? (placement in the value chain, support, knowledge developers, job creation, value creation, etc.)
2. How would you describe your expertise in the field of technology?
   - What is the degree of maturity of the technology?
   - What skills are needed for your business (in terms of technology)? Do you have it in house? Where do you find your skills?
3. Cause and results of various VINNOVA projects (including possible cumulative effects)
   - Why did you participate in **several different** VINNOVA projects?
   - Did you get what you expected? / What did you get out?
   - What would you have done if you had not participated in current VINNOVA projects?
4. Is VINNOVA's role (significantly) different in the consortium-based forms of intervention compared to the targeted SME action?

Questions about COLLABORATION:

1. Have the VINNOVA projects meant that you have interacted with other actors?
   - what kind of **interaction?** (e.g. technology, product/design, market, etc)
   - What kind of **actors**? (e.g. other companies, other financiers, universities/colleges, institutes, etc.)
   - What has been the interaction?
2. What is the result of this interaction? (direct **impact** on the project and on the company) (intangible assets, economic value-creation, job creation?)
3. What types of collaborations have over time been **most crucial** to you? (and in what way?)
4. Have the projects contributed to **changes in ownership**?
   - Group structure/conversion
   - Acquisitions, (that you have been acquired? That you yourself acquired?)
   - The creation of new companies (spin-off companies, sister companies, etc.)?

How have you affected others? (i.e. Who benefits from indirect spill-over effects? As well as System-level effects)

5. How have you influenced other actors?
   - type of partners/**actors** affected (companies (customers, suppliers, competitors, consultants, etc.), universities/colleges, institutes, networks of actors, etc.)
   - has this created **effect** on other actors (intangible assets, economic value-creation, job creation?)
6. Have you had an impact on the functions of the system:
   - Knowledge development/dissemination/direction of search?
   - regional labour market and resources (e.g. skills, specialists and subcontractors)?
   - conditions for the start-up of new companies (Stimulation of entrepreneurship/entrepreneurial experimentation)
   - creating new markets and/or business models (external orientation – i.e. the identified new opportunities (or problems)?
   - legitimacy/regulations/laws etc??
   - Other?
7. When have different effects occurred and how do different effects relate in time?
8. Have the VINNOVA projects played any role here? Which?