Version 27.2.2017

Towards next generation PPP models – insights from an agency perspective[1]

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[1] We are indebted to Lennart Stenberg, Tuomo Alasoini, Tuula Savola and Timo Hämäläinen for insightful comments on earlier versions of this paper. All arguments and interpretations expressed in this paper remain our own personal ones.

1 Introduction

1.1 Background

The innovation systems approach has been very successful in inspiring innovation policies and funding agencies around the world. The approach was originally applied in the Nordic and European context based on earlier analysis of the Japanese post-war model of industrialization (Lundvall, 1992; Nelson, 1993). Thereafter, the approach spread globally through work at the OECD and other think thanks.

Key features of this innovation system approach include the idea that knowledge transfer should be supported in a systematic way and that the state can play an important role by, among other things, facilitating public-private-partnerships (PPP)[2]. The role of science-technology-industry collaboration has been at the core of many subsequent PPP- models such as the center of excellence SHOK program in Finland, the sector programs in Sweden and other European countries (e.g. the Spitzenkluster program in Germany, the COMET programs in Austria, and the TKI programs in the Netherlands) (TAFTIE, 2016). However, while these basic insights of an innovation system approach still hold, globalization and the changing nature of innovation bring new challenges for PPP programming. In addition, the increasing urgency and complexity of societal challenges is also calling for new approaches.

Innovation policy in many OECD countries is reacting to these challenges for traditional PPP models. For example, the need for broad-based policies that can address societal challenges is acknowledged. Structural reforms, as well as new policy instrument development, are also taking place in order to facilitate better cross-ministerial coordination, incentivize the research system to respond more directly to societal needs, or even grand challenges, and enable new types pf PPP models to develop. Typical to broad-based policies is their emphasis on supporting transitions towards renewable energy, smarter cities, electric vehicles, digitalization of healthcare etc. through a more versatile mix of funding and other policy instruments that influence innovation both from the supply and demand side (Kuhlman & Rip, 2014).

Theoretical frameworks are also emerging that can help in policy design, perhaps most significantly those that relate to socio-economic transitions, transition management, adaptive governance and evolutionary targeting (see e.g. van der Berg et al.,2011, Loorbach & Rotmans,2010), Weber & Rohracher,2012, Karo & Kattel, 2016). Nonetheless, our claim is that new PPP program models that actually address some of the new types of failures that arise due to these changing trends and policy ambitions still are rare. Furthermore, where they do exist, their impact – and transformative ability – is often hampered by a variety factors regarding governance, policy coordination, reflexivity and scalability, among other things. In other words, the impression is that PPP program practices lag behind real-life trends and challenges that we currently are witnessing, and that they may not yet be addressing some of the new types of failures these trends gives rise to. This viewpoint is also very much in line with Mazzucato (2016) and her argumentation that the state should not only be perceived as passive corrector of market failure but rather as an entrepreneurial partner with a broader range of roles in stimulating innovation.

[2] PPP programs is a broad term that captures a range of different types of public policy programs. We define traditional PPP programs as cooperation programs on selected technology areas or sectors often between industry, academia and/or research institutes with public funding support. Later on in this paper we provide new interpretations of PPP programs based on recent developments and theoretical contributions.

1.2 Aims and structure

This paper will take an RDI policy agency perspective on the trends and theoretical insights that are challenging PPP program model design. It will identify emerging 'next generation' PPP program models that are responding to some of the trends highlighted above, and discussed in greater length in section 2, and analyze to what degree they are aligned with theoretical insights on new types of socio-economic failures that the trends give rise to. Specifically, the paper addresses the following research questions:

1. Which trends and developments in the global landscape are the most challenging for PPP programing at the national level?
2. Which types of new PPP program models are emerging in response to these trends and developments, to what degree and how are they addressing new types of socio-economic failures beyond pure market failures?

The paper will draw on years of joint practical experience and first impressions from emerging PPP program models especially in Sweden and Finland, with the aim of deepening and expanding the analysis also to some other European countries in future research. It will complement the innovation system perspective with new insights from the literature on transitions, transition and niche management, and evolutionary theory, as a possible way forward for policy-making in a complex global world where societal challenges are increasingly wicked and urgent but also create major new global market openings.

The paper is structured as follows. Section 2 discusses some ongoing trends that are creating new challenges but also opportunities for innovation policies and PPP programming. These trends mainly relate to globalization and digitalization, as well as societal challenges in areas of common concern to all such as climate change, resources constraints, and healthcare. The trends provide incentives for new modes of innovation and they pave the way for entry of many new types of actors that should also be relevant for PPP programs. Section 3 then considers how these trends have been reflected in the evolution of frameworks for innovation policy, and by extension in PPP programming. The section also reviews some key theoretical concepts that are useful for defining, identifying and analyzing next generation PPP programs.

In section 4 we move on to identify and briefly analyze some emerging PPP program models in Finland and Sweden which, based on our analysis, could be reasonably good examples of such next generation PPP programs. Finally, in section 5 we conclude with a synthesizing discussion and by highlighting some future research needs and challenges.

2 Globalization and new modes of innovation as challenges for PPP programs

2.1 Changing global innovation landscape

In recent decades the global innovation landscape has changed dramatically. Research and innovation are now generated by a wider range of countries, regions and actors than maybe ever before. As described by Athreye and Cantwell (2016):

> *"…the rapid globalization of S&T since the 1990s has been both remarkable and also something of a puzzle… First, the speed (…) is unprecedented. Second, the direction (…) marks a distinct break from past trends because it has encompassed some fast-growing urban*

regions in countries (…) that, until very recently, have not engaged in activities near the scientific frontier that depend on a substantial scientific infrastructure". (p.75)

Technological developments have increased the global connectivity and flows of knowledge, data and people while globalization has accelerated technological development underlining the mutually reinforcing nature of the two phenomena (Archibugie and Iammarino, 1999). Significant increases in investments in science and technology particularly in China, but also in other emerging countries, have shifted the global distribution of knowledge and innovation resources in favor of Asia. Asia's rise is confirmed further by the fact that according to a survey by PWC (2015), in 2015 Asia was the number 1 destination for corporate R&D spending, followed by North America and Europe, while in 2007 the order was reversed. Knowledge is also generated to a larger extent in international collaboration, as can be seen, for example by the rise of the share of international co-publications as a share of total scientific publications in many countries and regions (see for example Vetenskapsrådet, 2016 and Royal Society, 2011). As a result, knowledge is increasingly globally generated, dispersed and utilized.

A consequence of this changing global innovation landscape is that "[g]lobal competition for talent and knowledge-based assets is on the rise" and innovation policies focus increasingly on the ability of countries and regions to attract these resources (OECD, 2014, p.39). With greater globalisation and inter-dependence in the fields of science, technology and innovation, national innovation policies increasingly seek to improve domestic advantages in global value chains (GVCs) to attract their innovation-related activities (R&D, design, etc.).

In addition to the changing global geography of knowledge, innovation processes are involving new actors, processes and sectors. Policymakers are trying to drive and strengthen innovation in the public sector in response to growing budgetary pressures and changing demands on healthcare, education and the general provision of public goods and services. The growing importance of emerging markets is pushing companies to focus more on frugal or reverse innovation – the latter being a phenomenon whereby companies first develop products for developing countries and then adapt them to high-income countries. The rise of the sharing economy, digitalization, crowd funding and open, social and demand-driven innovation are changing the drivers of innovation and more generally the context in which it takes place. Innovation is no longer mainly driven by scientific breakthroughs that are commercialized in large companies or high-tech startups in highly developed countries. Instead we are witnessing the emergence of new innovation spaces, but also new "sponsors of science" and new "knowledge production communities" (Kuhlmann and Rip, 2014, p.8).

2.2 Grand challenges and market opportunities

A further impetus to revisiting research and innovation programs is that innovation policy is driven by an increasingly urgent need to address societal challenges, sometimes also referred to as 'Grand Challenges', a term coined in the Lund Declaration adopted during Sweden's Presidency of the European Union in 2009. The declaration identified global warming and access to resources, energy, food and water, ageing population, health, pandemics and security as key societal challenges and called for European research to "move beyond current rigid thematic approaches" and instead focus on addressing these challenges.[3] Furthermore, the experience gained from running research and innovation programs has led to growing realization and concern that technological progress or innovation do not automatically lead to workable solutions to address climate change, pollution or ageing societies. We thus see a shift from innovation

[3] https://www.vr.se/download/18.249c421a1504ad6d28144942/1444391884365/Lund_Declaration_2009.pdf

policy aimed at promoting innovation in general, and some might argue indiscriminately, as a means of strengthening competitiveness and economic growth, towards an expectation that innovation and innovation policies should lead to the development of solutions to identified problems or societal challenges, sometimes also referred to as a more directional innovation policy.

The changes described above, in turn, require new approaches to designing, implementing and evaluating research and innovation programs and policies. More specifically, they also require new PPP-models. According to Kuhlman and Rip (2014), innovation policies and programs to address grand challenges require "open-ended missions, and missions concerning the socio-economic system as a whole, even inducing (or requiring) *system transformation*" (p.1). They require "tentative policy mixes", "facilitating system changes", "demand-side and procurement policies", "system-oriented strategic interventions", experimentation, "out-of-the-box approaches like new combinations of actors and alliances", including for example, NGOs and foundations (ibid, pp.4 and 10). Crucially, they also require a different role of government, going beyond R&D programs and funding. Government is called upon to act as 'orchestrator', 'creator' or 'enabler' of "spaces for interaction towards innovation" (ibid, p.9). Finally, grand challenges call for "open-ended initiatives" and "tentative governance" rather than master plans (ibid).

2.3 Sweden and Finland in this changing context

From an innovation system perspective, Finland and Sweden share a number of common features. They have been two of the top countries in the OECD when it comes to R&D spending as a percentage of GDP and they tend to rank at the very top in international innovation rankings (such as the European Innovation Scoreboard or the Global Innovation Index). They both have a strong tradition of industry-academia collaboration and PPP programs, though on the industry side, collaborations have been quite dominated by large companies in both countries. Similarly, in both countries, a relatively small number of large companies has accounted for a large share of both business R&D and total R&D (since in both countries corporate R&D expenditure accounts for the lion's share of total R&D expenditure), though this has been more pronounced in the Finnish case with the dominance of Nokia. Both countries have had technology or innovation agencies, Tekes and Vinnova, which have played important roles in channeling public funding for research, development and innovation.

There are also some significant differences between the two countries. Research institutes have played a bigger role in the Finnish research system than in Sweden, measured by research performed in the institute sector. Finland has performed very well in the OECD Pisa rankings in the past decade(s), which seeks to compare the quality of secondary education in different countries, while Sweden's ranking has been rather low. Finally, whereas Sweden has fared quite well since the global financial crisis in 2008, in terms of GDP and unemployment, Finland's economy has been hit comparatively hard. As a result, whereas public expenditure on research and innovation has increased significantly in Sweden in the past decade, particularly funding to universities, Finland has experienced stagnating or even shrinking expenditure, with significant cuts in basic funding for research institutes and in Tekes' budget while funding for universities has stagnated (after having increased steadily for many years).

In response to the changes in the innovation landscape described above a number of reformulations in both policy focus and initiatives has taken place in Sweden. Firstly, there is an increasing emphasis on societal challenges in research and innovation programs, as illustrated, for example, in the Research Bill presented by the Swedish government in November 2016, which is entitled 'Knowledge in cooperation –

for society's challenges and strengthened competitiveness'.[4] Innovation programs are also targeting new actors and processes. Initiatives to promote innovation in the public sector and social innovation are examples of this. While policy has traditionally identified and targeted research and commercialization of research as universities' key contribution to innovation, recently there has been increasing acknowledgement of the importance of innovation and a focus on students as important innovation actors. The establishment of the Swedish Innovation Council chaired by the Swedish Prime Minister signals a growing attention to the governance of innovation policy. Finally, we also see a stronger emphasis on demonstration activities, test beds and policy experimentation, as well as the demand side of innovation – for example through innovation procurement.

In Finland, the establishment of the Strategic Research Council (SRC) at the Academy of Finland reflects a growing focus on tackling societal or 'grand' challenges and on strengthening evidence-based policymaking for system innovation or transition. The SRC funds multidisciplinary research projects on 'real-world' problems of clear policy relevance. Experimentation, an important element of system innovation and transitions theory, has been identified an essential element of the Finnish government's efforts to solve complex societal problems and is one of five principal objectives for implementing Finland's 'Vision 2025', along with digitalization and deregulation. Experiments are encouraged at various levels of policymaking with some strategic experiments, such as the one on basic income, based at the very highest level of government, at the Prime Minister Office's Experimental Unit. The recent relaunch of the Research and Innovation Council as well as the pooling of analytical resources and research at the Government Policy Analysis Unit at the Prime Minister's Office, indicate a renewed interest in horizontal policy coordination and strengthened governance of research and innovation policy.

Similarly to Sweden, Finnish innovation policy also gives more emphasis on demonstration activities, test beds as well as the demand side of innovation e.g. through regulatory reform and programs that aim to develop competencies and better prerequisites for innovative procurement in the public sector. However, due to sluggish economic growth, the Finnish innovation policy seems to focus more on innovation-driven exports for emerging global markets created by the new societal challenges. However, there are also new initiatives to strengthen the link between societally-oriented research and innovation within companies such as the Challenge Finland funding scheme by Tekes, the Finnish Funding Agency for Innovation. The role of Sitra, an agile future-oriented public "think-and-do-tank" whose work currently focuses on system innovations, should also be highlighted.

3 Towards new frameworks for innovation policy

3.1 From R&D to system of innovation policies

Innovation policies emerged from empirical findings after World War II that highlighted the significance of science and technology for productivity, economic growth and prosperity. In the 1980s and early 1990s, these findings were incorporated as an endogenous component in economic growth models. This replaced the traditional view that scientific and technological change originated outside the economic system as 'manna from heaven'. If science and technology indeed were endogenous and driven by economic factors,

[44] http://www.regeringen.se/rattsdokument/proposition/2016/11/prop.-20161750/

a logical follow-up question was what role should the state play in this context. This question was addressed in seminal papers by Nelson (1959) where the focus was on market incentives for undertaking research and development activities. Their important conclusion was that markets often fail to incentivize a societally optimal level of R&D due to knowledge spillovers to competitors. However, these spillovers also play a central role in escalating the effects of R&D beyond the growth of individual companies to the level of whole nations.

During the 1980s and 1990s it became increasingly apparent that growth convergence between R&D intensive countries was happening at a much slower pace than anticipated. This observation led many scholars to re-examine the popular model of innovation that assumed relatively linear relationship between R&D investments and economic growth. Schot and Steinmuller (2016) single out important findings from the literature that also influenced policy thinking to a significant extent. First, R&D is not necessarily always a public good but tends to be 'sticky' and accumulate in certain locations. Absorptive capabilities are also needed to make economic use of R&D and these capabilities need to be systematically built throughout networks. Finally, R&D is path-dependent and cumulative in the sense that structures and institutions strongly influence both the direction and speed of technological change. Disruptive changes, such as the transition to a fossil free economy, therefore also require fundamental structural and institutional change throughout society.

Following these, and other, research findings more interactive models of innovation gained in popularity all the way from the chain-linked model of innovation by Kline & Rosenberg (1986) to systems of innovation literature by Freeman (1987), Lundvall (1992), Edquist (1997) and others. The system of innovation literature has been especially influential for policy design and implementation, not the least in Finland and Sweden. The system of innovation approach directed attention to various organizational and institutional set-ups that advance learning and the flow of knowledge for innovation in countries. A central idea was that some countries have more conducive organizational and institutional set-ups than others and therefore are better at accumulating, transferring and making economic use of knowledge for innovation. These differences were also considered as a reason for lack of growth convergence despite increasing R&D intensities across many countries.

The systems of innovation literature complements market failures arguments as a rationale for innovation policy by highlighting a broader view where R&D only is one contributor to innovation. The emphasis shifts to various factors that facilitate the flow and absorption of knowledge and to the various other types of 'system' failures that are associated to these. These failures may relate institutional bottlenecks in the shape of regulations, laws or taxation that block the advancement of technologies or the uptake of innovations. They may also relate to lack of partnerships between different types of actors in regions or countries and insufficiencies in infrastructures to support such partnerships, such as incubators, science and technology parks, centres of excellence etc. The innovation system literature has also stressed the importance of interactions between producers and users of innovations and factors that may hinder these interactions. For example, Edquist (2000) and others have highlighted the potential of public procurement as a demand-based policy instrument to boost innovation.

The system of innovation literature has evolved and expanded in various directions. An important extension is that of the triple helix model (see Etzkowitz, 1993; Ranga and Etzkowitz, 2013). The triple helix model provides a more granular view of interactions between the government and industry by focusing on the different roles that universities can play in the system of innovation. It draws attention to the

shortcomings of the focus of the innovation systems approach on the interactions between actors but its neglect of the capabilities and various roles that they may play in stimulating, or even hindering, innovation.

Mazzucato (2015, 2016) provides an additional complement to the systems of innovation literature through her attention on the 'entrepreneurial state'. She argues that the state can have a much more multi-faceted role in innovation systems beyond merely funding R&D. The state also plays an important role in "de-risking" private sector activities in the diffusion and industrial uptake of innovations. It can show strong leadership in creating new technological opportunities and markets through a more strategic and mission-oriented role. This role can manifest itself in that the way that the state, and various government agencies, define a challenge or problem to be solved by R&D, setting up standards for R&D activities to live up to, or stimulate innovations through smarter regulations and public procurement. She suggests that these various other roles of the government help in providing strategic direction for private sector R&D by providing more a more favorable balance between risks and rewards as companies engage in uncertain R&D and innovation.

3.2 Managing complex transitions

As we have suggested a better understanding of non-linear innovation processes and various system-level failures have broadened the scope of PPP programs from a focus on university-industry R&D collaboration towards models which more clearly also seek to facilitate interactions and collaboration between various types of other actors. However, recently many scholars have argued along similar lines as Mazzucato (2015 & 2016) that this broadening may not be enough (see especially Weber & Rohracher, 2012, Schot and Steinmuller, 2016). They claim that the underlying assumption of contemporary PPP models still is based on a too linear assumption that R&D leads to innovation as long as system-level failures, such as regulations, are addressed. Another point of concern relates to trends discussed in section 2 that are starting to challenge innovation policy and contemporary PPP models in a major way. Globalization is challenging traditional nationally oriented governance arrangements. Digitalization, in turn, is increasing complexity and changing the nature of innovation in fundamental ways, e.g. by creating new types of platforms for new types of partnerships. Finally, the increasing urgency of societal or 'grand' challenges is also calling for new approaches both within policy and company strategy as they also open up major new markets.

Transition theory has emerged in response to the need to analytically grasp and act upon societal and wicked challenges, especially to redirect sectors and whole societies onto an environmentally more sustainable development path. Scholars in this tradition argue that the systems of innovation approach mainly focuses on how to optimize the organizational and institutional systems that support innovation but do not provide sufficient insights into how to handle this redirection, or transformation, of sectors and whole societies. They propose the so-called multi-level perspective to stress that transitions require changes at the level of the broader landscape for innovation, in the institutional and regulatory regimes of sectors, as well as changes within the sectors themselves through entrepreneurial actors (see Figure 1) (Geels, 2002). This multi-level perspective has been enriched further especially by the literature on transition and strategic niche management. The former refers to ways in which policy can 'manage' transitions while the latter refers to how disruptive entrepreneurial 'niches' emerge and can be nurtured to gradually overturn existing sectors and regimes.

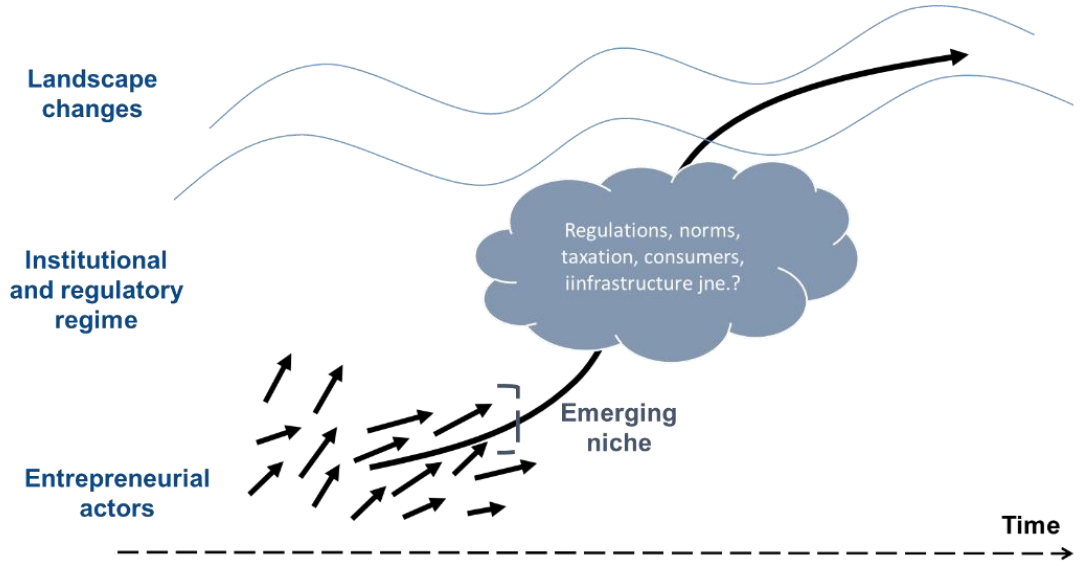


Figure 1. The multi-level perspective, builds on Geels (2002)

Transition management emerged out of evolutionary and complexity theory and was introduced as an official government policy in the Netherlands especially in the area of climate change mitigation (Loorbach & Rotmans, 2010). This policy scheme broke with dominant policy traditions and practices by creating space for innovative policy experiment for transitions in Dutch regions. Transition management is should be practiced in four major steps, all of which aim to foster experimentation and facilitate the emergence of new niches by entrepreneurial activities of frontrunners. The first step is to structure the problem at hand, define the challenge or socio-technical goal that is to be achieved. This should involve the setting-up of so-called transition arenas to allow for experimental activities by the frontrunners, or companies and other actors (e.g. regulators, consumers, civil society) whose aspirations are in line with transformational goals and who can challenge the status-quo in a viable way.

The second step involves developing a joint agenda and roadmaps to achieve the socio-technical goals (for example specificities in the transition to the bioeconomy). The third step is to engage in experimental innovative activities in line with the road map to reach the goals. These experiments may be competing and overlapping since the optimal way forward seldom is in sight. The experiments also start to mobilize and self-organize a broader set of actors and stakeholders around specific transition pathways. Often these emerging networks, or business ecosystems, may experience infighting and conflicts about the pace and direction of changes. Transition management therefore also has to cater to conflict management and the risks that transition processes may become hijacked by incumbent actors who wish to retain the status-quo. The fourth step involves continuous monitoring and evaluation of transition experiments and pathways to ensure reflexivity, openness and continuous adjustments. (Loorbach & Rotmans, 2010).

Strategic niche management complements transition management insights by highlighting the importance of transition arenas for nurturing emerging niches and related ecosystems. Niches refer to those specific economic and institutional contexts where transition experiments and pathways unfold and new ecosystems emerge, gain strength and direction to challenge incumbents. Strategic niche management does not equal to infant industry arguments. Rather, niche management requires flexibility for how incentives are set, how regulations and other institutional barriers for emerging ecosystems may be lowered, as well as how users or consumers better can start to engage and use new technologies as solutions for socio-technical challenges and related markets. This may involve setting-up demonstration

plants and testing sites, it may involve temporary tax reliefs or regulatory flexibility for using new products and services. It can also involve various new ways in engaging civil society in new ways to support early adoption of emerging technologies (Schot & Geels, 2008, Schot & Steinmuller, 2016).

3.3 An analytical framework for PPP program alignments

The transition and niche management literature outlines rather different rationale and role for innovation policies compared to traditional market failure theory, especially when the aim is to addresses grand challenges and related market opportunities. Policies should continue to support R&D but also need to address various non-R&D related failures that arise due to mismatching structures and suboptimal systems of innovation in sectors and countries. The failures may also relate to lack of directionality and market formation to support emerging niches, or business ecosystems, and changes at the regime level. The literature reviewed above thereby also challenges traditional ways of thinking about PPP programs where the focus mainly has been on supporting R&D through centers of excellence, industrial or regional clusters etc. with the main purpose of connecting research with industrial needs.

An interesting question is whether and how innovation policies and agencies are reacting to the trends discussed earlier in this paper as well as to emerging theoretical and empirical findings as they design or redesign their PPP models. A recent report on experiences from the mutual PPP learning exercises within the EU suggests that new types of PPP models are emerging but that they still are scarce and only starting to address non-R&D related failures throughout innovation environments and systems across countries. The report concludes by identifying some characteristics that such next generation PPP program models should have in order to be aligned with the way that the world has changed (DG RTD – H2020 policy Support Facility, March 2016):

> "[next generation PPPs] *represent a shift from short-term contracts with a relatively limited scope to longer-term, horizontal commitments frequently to address strategic and challenge-driven questions with a long-term vision connecting with governmental priorities. They are horizontal multi-partner arrangements, often among otherwise competing partners, that have a unifying goal. Unlike traditional project-based research and innovation programmes, where a state agency defines a programme and contracts with researchers and companies to implement the projects of which it is comprised, such PPPs involve sharing not only the act of programming but also governance"*.

In this paper we need a framework to capture more analytically key features of the emerging next generation PPP models that we have identified in Sweden and Finland in order to discuss to what degree they appear to be aligned with the trends and theoretical insights. Weber and Rohracher (2012) provide such a framework in their important article on legitimizing innovation policies for transformative change. Their framework amounts to a taxonomy of different types of failures that innovation policy, and by extension PPP program models, should seek to address when the aim is to stimulate transitions of more radical nature. The taxonomy is summarized in table 1. We will refer to it, and elaborate further, throughout section 4 as the analytical framework for assessing the alignment of emerging PPP models in Sweden and Finland.

Table 1. A taxonomy for assessing next generation PPP program models

Structural system failures			**Transformational failures**			
Institutional evironment	Interactions	Change and conflict management	Directionality	Demand articulation	Policy coordination	Reflexivity and openness
Absence, excess or shortcomings of formal institutions or infrastructures	Lack of interactions across sectors, companie and other actors Path-dependency and iock-in to sub-optimal interaction	Lack of capabilities to change and react to landscape movements, approaches in place to mitigate conflicts	Lack of shared vision for direction of change based on needs of industry and society, lack or change urgency	Insufficient links to market demand, understanding of consumers, users	Lack of coordination across ministries, agencies and other policy stakeholders	Insufficient ability to monitor, anticipate landscape changes, involve new actors, experiment etc.

At this point we wish to reiterate that the types of transitions that the literature mainly refers to in the context of more sustainable development (e.g. the transition to the bioeconomy, smarter cities or transport) often take decades to unfold. Further, the transitions require an interplay between various policy- and other changes at the level of the broader landscape, institutional and regulative regime, and entrepreneurial activities across firms, research groups and other stakeholders. Hence, a specific PPP program can only have a limited role at a specific point in time in a broader transition, as an initiator for entrepreneurial activities within new niches and perhaps also as an initiator for changes in the institutional and regulative regime.

Further, when the taxonomy is applied one should also be considerate about these broader landscapes, the institutional and regulatory set-up of countries and sectors, as well as entrepreneurial activities beyond those that are contained within a specific PPP program. We refer to this taxonomy with these caveats in mind. We propose that the taxonomy, at best, can highlight whether PPP programs that we use as examples appear to be designed in a way that some of these non R&D-related failures may be addressed more sufficiently compared to traditional PPP models. We can also highlight to some potential challenges that the PPP programs are facing/may be facing in the future when they address these non R&D-related failures. However, we cannot make any far-reaching judgement to date about the specific contributions of the programs to broader transitions in Sweden and Finland to which they aim to contribute.

Returning to the taxonomy by Weber & Rohracher (2012), it distinguishes between *market, structural system and transformational system failures*. *Market failures* refer to well-known informational asymmetries, knowledge spillovers and cost externalities that may produce sub-optimal investments in R&D. They constitute the backbone argument for RDI-oriented PPP programs and they will not be covered in our analysis, and thus are also excluded from Table 1. *Structural system failures* refer to lack of infrastructures, absence or excess of formal institutions such as laws, regulations or standards, social norms, values and culture that can block innovation. They may relate to the absence of collaboration between actors, or too tight and introvert collaboration that may lead to lock-in to incremental trajectories. Structural system failures may also relate to lack of appropriate competences and resources at actor and firm level that lead to an inability to adapt to changes and new opportunities.

Market and structural system failures are quite well understood and acknowledged in policy circles. It seems fair to say that these understandings have, explicitly or implicitly, influenced PPP program design in many countries. *Transformational system failures* are much fuzzier and have only recently entered the

policy discussion also at such fora as the EC, World Bank, UNEP and OECD. These failures relate to lack of shared vision regarding the goal and direction of the transition process, inability to coordinate change agents in transitions, insufficient regulations, standards and other institutions to guide the change, lack of targeted funding for innovation and demonstrations to support new and experimental pathways. The failures may relate to lack of understanding of user needs, absence of orienting and stimulating signals from public demand (including public procurement) and lack of demand-articulating competences. They may also related to poor coordination across different policy domains and executive branches of government, between regional and national policies, or between national and transnational policies (for example related to lead market initiatives at the EU level). Finally, transformational system failures may relate to the inability of agencies and other PPP stakeholders to monitor, anticipate, and involve all relevant actors. A lack of this this type of openness and reflexivity can hinder self-organization, experimentation and can lead to the exclusion of change agents that bring radically new ideas and challenge incumbent players.

4 Exemplifying insights from next generation PPP programs in Sweden and Finland

4.1 The case of Sweden, the SIO and UDI programs

In recent years, the Swedish government agency for innovation, Vinnova, has launched two programs that could be argued to exemplify next generation PPP-models. Common to both of these models is that they seek to tackle societal challenges and to promote transformative change or system innovation. The first is the program called 'Challenge-Driven Innovation-Societal Challenges as Opportunities for Growth' launched in 2011, also referred to as 'UDI' (short for 'Utmaningsdriven innovation'. The other is the 'Strategic Innovation Area Program' also referred to as SIO, launched in 2012.

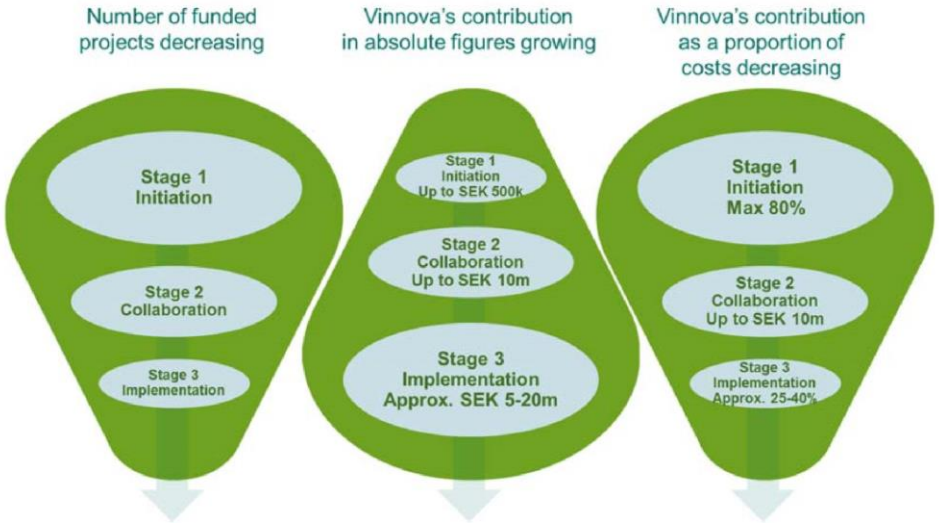
For the UDI program, based on a consultation process with a wide range of stakeholders, Vinnova identified four areas of societal challenges "in which Sweden has good prospects of leading the field with new innovations": future healthcare, competitive industries, sustainable attractive cities and information society (Vinnova 2016, p.7).

Vinnova sets out the following principles that should govern the evaluation criteria for project selection within the program:

- "Be based on a critical need in society and the business sector, which can clearly be associated with organisations or equivalents that own the needs
- Result in innovations that combine international business potential and social benefit,
- Build on collaboration between actors in value chains that involve users, customers and other relevant stakeholders in the process,
- Further develop and utilise infrastructures for innovation that both promote the integration of systems (information, communication, standards, transport) and create an opportunity to test innovations under market conditions,
- Include a systemic approach – addressing the whole of the innovations system, not just the parts,
- Promote and stimulate collaboration and interaction between the actors needed for successful utilisation,
- Pursue development of new opportunities that the market itself is not developing." (Vinnova 2016, p.6)

A stage-gate approach is applied with three stages in which Vinnova's contribution as a proportion of the total budget decreases while its contribution in absolute figures grows (see Figure), as projects move closer to the testing and implementation phase. The number of projects funded decreases while the size or scale of the individual projects increases. Overall, the approach is to start broad and sharpen the criteria along the way. However, it is not necessary for project to have received funding in stages 1 and/or 2 to receive funding in stages 2 and/or 3.

Figure 1: Vinnova's stage-gate approach in the UDI program



Between 2011 and December 2016, Vinnova had allocated slightly over 1 bn SEK (around 110 m Euros) to UDI projects. In 2016, there were 221 ongoing UDI projects in total.

The SIO program was formally created in response to a formal task assigned to Vinnova, the Swedish Energy Agency and the Swedish Research Council for Sustainable Development (Formas) by the Swedish government in 2012 to identify and support strategic innovation areas. However, prior to the formal assignment Vinnova had already developed precursor initiatives. Thus, the development of the SIO program can be said to have been the result of an iterative process between the Ministries of Enterprise and Research and Education and Vinnova. The purpose of the initiative is "to create conditions for strengthened international competitiveness and sustainable solutions to global societal challenges" (Vinnova, 2013, p.3). Specific goals are to renew Sweden's innovative strength in a number of strategic areas, to develop new value chains and to strengthen cross-sectoral competence, knowledge, technology and service development (ibid).

An important feature of the SIO program was that the selection of the strategic areas was bas based on a bottom-up process. As described by the OECD:

> *"Critically, however, the Bill also stated that it was not up to government to decide which areas were deemed strategic. Rather, this should be decided through establishing bottom-up processes allowing the innovation actors themselves to define priority areas, with government facilitating the process and establishing a framework of selection criteria reflecting societal challenges, high scientific quality, collaboration, cross-disciplinarity and co-financing. These criteria were also expected to govern the choice of activities conducted*

within these areas, with the community itself responsible for proposing and, importantly, managing the activities". (OECD, 2016, p.108).

In the first phase and to identify areas which could be deemed 'strategic', innovation actors were invited to formulate 'Strategic Innovation Agendas'. The purpose of this step was to encourage actors to work together to define common visions, objectives and strategies in areas of their own choosing. Vinnova offered seed funding to actors to work together in this process.

In the second phase, consortia were invited to submit applications for funding of SIO programs. Funding for them is initially provided for three years, "with the possibility of renewal for a maximum of nine further years based on review processes every three years" (OECD, 2016, p109). Thus, a further key characteristic is the long-term horizon of the program.

As of December 2016, there were a total of 16 SIO programs. Between 2013 and 2016, the total public budget for the SIO initiative amounted to around 1.1 bn SEK (roughly 120 m Euros). Between 2017 and 2024, around 600 m SEK (ca. 62 m Euros) annually have been budgeted for the initiative. Many of the large Swedish-based companies are involved in one or several of the SIO programs.

Table 2. The SIO programs

Programs	**Program Office**
Lightweight materials	Swerea
Metallic materials	Jernkontoret (Swedish Steel Producers' Association)
Mining and metal extraction	Luleå University
Production 2030	Teknikföretagen (Association of Swedish Engineering Industries)
Process industrial IT and automation	SICS Swedish ICT
Aeronautics	Svensk Flyg (Swedish Air Transport Society)
Graphene	Chalmers
ICT electronic components and systems	Acreo Swedish ICT
Internet of things	Uppsalas University
Bio-innovation	Skogsindustrieran (Swedish Forest Industry Federation)
Life Sciences	Lund University
Automated transport systems	Lindholmen Science Park
Resource and waste management	SP Technical Research Institute of Sweden
Smart built environment	IQ Samhällsbyggnad (Swedish Centre for Innovation and Quality in the Built Environment)
Medtech	KTH
Future transport infrastructure	KTH

In 2016, UDI and SIO together accounted for roughly one third of Vinnova's total program budget, with their share expected to increase to roughly one half in the coming years. Thus, these two programs account for a significant part of Vinnova's total portfolio.

4.2 The case of Finland, SUUNTA and the BioNets program

In Finland the need for transformative change, and system innovation, has also been high on the policy agenda in recent years. However, there are fewer examples of new PPP programs launched on a similar

scale and scope as the SIO and UDI programs in Sweden and which would explicitly focus on addressing specific grand challenges or transitions. Transformative change pressure stem mainly from a need to renew traditional sectors in the wake of the globalization, offshoring and the decline of Nokia's mobile telecommunications business. The clearest references to grand challenges in science policies have been made in relation to the newly established Strategic Research Council at the Academy of Finland. In innovation policy, grand challenges and related transitions are also often highlighted, albeit from the viewpoint of the global market opportunities that they can create.

The Center of Excellence (SHOK) program has perhaps been the prime example of a traditional Finnish PPP model that aims to link research to industrial needs through jointly defined strategic research agendas and some degree of shared governance between the funders and coordinators of the programs. The SHOK program was launched in 2008 but came to an abrupt end in 2016 due to government decision that was based on critical evaluations of the SHOK programs as well as the need to cut public expenditures (Lähteenmäki et al, 2013). Since 2008 the RDI program portfolio of the main innovation policy agency, Tekes – the Finnish Funding Agency for Innovation, has evolved from technology- or sector-specific programs towards programs that are more cross-cutting by nature and explicitly aim for transformative change e.g. related to the bioeconomy, digitalization, transport and healthcare. These programs have involved a larger set of actors beyond research organizations and companies and thus have some characteristics of next generation PPP programs as described in section 3 of this paper. They have also promoted the development of various test beds for system innovations to address grand challenges and related market opportunities. Examples of some of these recent cross-cutting programs are presented in table 3.

Table 3. Some recent examples of Tekes next generation PPP programs, Tekes funding shares are indicative for those programs that still are running

Program	**Aims and activities**
Green Growth, 2011-1015, 40 Meuro	Support transition to green growth by promoting new partnerships, consolidation of key stakeholders, R&D and demonstration projects
Electric Vechicles System, 2011-2015, 35 Meuro	Support the development of electrical vechicles ecosystem, testbeds and standardization, R&D and demonstration projects
Bits of Health, 2014-2018, 50 Meuro	Support customer-centered new digital healthcare innovations, develop new partnerships, engage in challenge-oriented match-making with health care providers and investors abroad
Witty City, 2013-2017, 40 Meuro	Support the transition to smarter cities through enabling testing and piloting of new innovative solutions and services, focus on ICT enabled solutions, new partnerships between research, companies and cities
5th Gear, 2014-2019, 50 Meuro	Support the shift towards next generation wireless data communications, develop test beds and new cross-industrial partnerships for new innovations and services

Cutbacks of RDI funding and the SHOK program, combined with structural reform of the research sector as well the increasing globalization and broadening nature of innovation, have fueled a discussion about the need and nature of next generation PPP program models. One important starting point for this discussion dates back to 2013 when the main innovation policy agencies (Academy of Finland, Tekes, Sitra, Finnvera, and Finpro) decided to join forces to develop a joint strategy for the development of new growth areas and ecosystems, the so-called SUUNTA strategy. The aim of this strategy work was to shift the focus of

innovation policy implementation beyond individual projects and companies towards the joint facilitation of the emergence of new business ecosystems in promising areas of economic activity in Finland.

At Tekes the SUUNTA strategy has implicitly been implemented in a range of recent programs. For example, the Green Growth embarked on an ambitious path to stimulate new partnerships across value chains in various industries to develop circular economy competencies also for global growth markets. The Witty City-program promotes ecosystems and new types of partnerships related to the application of ICT solutions for the transition toward smarter cities. The Bits of Health-program wishes to enable new business ecosystems related to digital health care solutions. The 5th Gear-program seeks to nurture testbeds and new business ecosystems at research and industry interfaces related to next generation telecommunications standards. The SUUNTA strategy has therefore already had some impact on moving Tekes RDI program activities beyond market failure arguments to also address 'system failures' related to new partnerships across sectors, as well as the broader institutional regime in so far as these programs also are influencing the regulatory environment for digitalization, healthcare, public procurement etc. They are also addressing some 'transformational failures' by contributing to defining strategic directions and shared visions, to some policy coordination (for example related to the realization of smarter cities), as well as to the articulation of demand and lead markets e.g. by providing strategic intelligence and market information.

Perhaps the best recent example of a next generation PPP program model at Tekes is the BioNets program, launched in 2016 to facilitate the emergence of new partnerships and ecosystems to develop new higher value-added biomass-based products. The BioNets program is a pilot program model that came out of the SUUNTA strategy work. The program model was developed during 2015 and launched in Autumn that same year through a three-stage approach. During the first stage a call was opened to fund the development of strategic visions and roadmaps on how Finland could accelerate the transition to the bioeconomy so that specific global market needs could be targeted with new biomass-based processes or products. The aim of this call was also to identify intermediating actors who would have the credibility, competencies and incentives to orchestrate business ecosystems towards realizing the vision through the roadmaps. Emphasis was on recognizing business opportunities in which Finnish companies could have a competitive edge. This first stage call contributed to several expressions of interest and eventually resulted in seventeen roadmap and orchestration applications. Of these applications six roadmaps and orchestrators were funded with the tasks to elaborate further on the roadmaps, visions and governance models for orchestration in collaboration with participating companies that are part of the emerging ecosystems. Elaborations continued during Spring 2016 in collaboration between the orchestrators, Tekes and other the other innovation policy agencies through joint workshops and bilateral meetings.

The second stage call was opened in late Spring 2016 with closure in early Autumn 2016. This second stage was to fund the orchestrators for implementing the roadmaps and visions in collaboration with key companies and other actors of the emerging ecosystem in the respective business areas. The funding covers various innovation-promoting activities other than traditional R&D projects. These activities are intended to strengthen cross-sectoral interactions and partnerships throughout the ecosystem and beyond, cater to institutional and regulatory bottlenecks that may inhibit the development of the business areas, to manage changes and conflicts, to strengthen further, and communicate, the joint vision, to articulate market needs and demands, as well as to ensure that the emerging ecosystems remain agile, open to new actors and also develop in line with the intended roadmaps. This second stage call resulted in the final selection of four ecosystems, respective roadmaps and orchestrators as displayed in Table 4. The total

funding ranges from 200,000 to 600,000 euros per orchestrator. However, these volumes will likely increase significantly in coming years as the ecosystems start to initiate larger strategic R&D projects and other activities beyond mere orchestration that requires public funding from Tekes or other agencies.

Table 4. The four BioNets ecosystems and orchestrators

Ecosystem	**Objectives**
New cellulose and fibre products, orchestrated by CLIC Innovation in collaboration with participating companies and other organisations that belong to the ecosystem	To turn expertise in wood fibre based textiles and composite materials into international business. Finnish companies have world leading know-how in creating methods that enable the manufacture of textiles and composites from wood fibres. The ecosystem interlinks expertise in this area with the piloting required for market entry, and creates the tools that start-ups need to drive their business forward. In addition to fibre and technology suppliers, the ecosystem includes end users that process fibre materials into consumer products.
Lignin ecosystem, orchestrated by Pöyry Management Consulting in collaboration with participating companies and other organisations that belong to the ecosystem	To bring Finnish players in the industry together to co-create a globally unique lignin ecosystem that connects technology suppliers, existing and potential producers, and refiners into a single network. In addition to the core network consisting of Finnish players, the ecosystem will also feature a large number of potential end user companies worldwide, representing sectors such as the chemical, forestry, mechanical engineering, coating, biofuel and aircraft industries.
Packaging Valley, orchestrated by Pöyry Management Consulting in collaboration with participating companies and other organisations that belong to the ecosystem	To create a novel and globally unique packaging ecosystem to guarantee that a regenerated and competitive packaging industry is retained in Finland. "Packaging Valley" provides an environment in which the Finnish forestry industry, the packaging industry, innovative SMEs, Internet of Things enterprises, software developers and security software suppliers can work together to promote digital packaging and materials development.
Nutrient recycling, orchestrated by Baltic Sea Action Group in collaboration with participating companies and other organisations that belong to the ecosystem	To achieve a breakthrough in nutrient recycling, create new Finnish business in the international markets, and increase the value of the nutrient recycling business. Business spearheads include future fertilizers, nutrient recycling and biogas innovations. Products and service concepts within this ecosystem are seeking to meet global demand arising from nutrient recycling.

The BioNets program model marks a departure from previous Tekes programs since the topics were identified bottom-up through roadmap suggestions by actors in the field rather than through consultations with ministries, pre-identified companies, research- and other stakeholders. The BioNets program initially, during the first stages, funds roadmaps and orchestration rather than R&D projects and thus has a stronger facilitating role to support self-organization in the field. R&D projects will become more prevalent once the ecosystems have fine-tuned their roadmaps and identified areas where major new competencies and demonstration activities are needed. Governance of activities is shared between Tekes and the orchestrators as opposed to previous program models where overall steering and coordination primarily has resided at Tekes although externally sourced program coordinators also often have been used.

An interesting feature of the BioNets program is also that a reference groups has been set up that consists of representatives from the main innovation policy agencies, including a few ministries, to achieve a better overall coordination at different levels of the system. The model is also intended to incentivize the orchestrators and partners to actively contribute to the ideation of new policy initiatives (e.g. match-making with other investors, hackathons, innovation competitions, international collaboration, export promotion) in the third stage, including R&D consortia and demonstration applications to cater to the needs for new capabilities and technologies in companies. This is to ensure that the roadmaps are implemented to their full extent as the ecosystems evolve over time. All orchestrators are private sector organizations while e.g. city administrations, university- or public research organizations were not considered to be the optimal orchestrators in this pilot phase. These types of public sector organizations were deemed to lack incentives and business models to support business ecosystem orchestration.

Even though these are still early days the BioNets pilot program has gained positive attention and appears to have succeeded in its' initial phases to activate and build new partnerships in the bioeconomy area. There are also signs of fruitful cross-fertilization between different disciplines, technologies and sectors. This PPP program model is also spreading to other Tekes focus areas and initial insights are utilized for further discussions on next generation PPP model in Finland. Meanwhile, the latest phase in the evolution of Tekes RDI program portfolio relates to intensified collaboration with Finpro, the Finnish export promotion agency that also engages in invest-in promotion. This collaboration opens up new avenues for promoting ecosystems and transformative change in different sectors through an even broader mix of policy instruments.

4.3 Analysis of emerging next generation PPP programs in Sweden and Finland

In this section, we examine to what extent the three programs, namely SIO and CDI in Sweden and BioNets in Finland, appear to be designed in a way that some of the non R&D-related system and transformational failures can be addressed in the context of the broader transitions that they aim to contribute to. We do this while acknowledging that specific PPP programs, such as these, only can have a limited role in promoting transitions. We make some references to other complementary policies and institutional contexts in Sweden and Finland, but leave further elaborations and deeper and more holistic analysis for future research. Our main contribution is therefore to provide some ideas for the further design and implementation of next generation PPP programs. We can also highlight some missing elements that need to be addressed by complementary policies, agencies or other stakeholders.

The transformative ambition is expressed clearly in Vinnova's description of its CDI Program.

> *"Vinnova's vision is that challenge-driven innovation is a vital, unique component of the Swedish growth and innovation engine. The greenlighted projects are of international eminence and develop sustainable solutions to tackle key societal challenges. The projects are visionary, challenge existing mental models and target systemic issues. These issues are characterised by a transnational character that requires a multidisciplinary approach. The results will lead to a more sustainable society."* (Vinnova, 2016. p.3)

In its review of Sweden's innovation policy in 2016, the OECD underlined that Vinnova's SIO program constituted a significant new departure from previous PPP programs:

> *"One key point that should be stressed at this stage is the revolutionary nature of this whole process compared to historical practice within VINNOVA. Conventional practice had been for*

> *government/VINNOVA to designate priority areas on a much more top-down basis, albeit one involving more restricted and informal consultation with key stakeholders. The most radical change involved the transfer of managerial responsibility for the SIPs to the program participants themselves, albeit with VINNOVA (and the other agencies involved) retaining the final say over which activities received funding". (*OECD, 2016, p.109)

The analysis is based on the taxonomy of non-R&D related failures that the literature on systems of innovations and transitions has identified as important for promoting transitions and systems innovations of a more disruptive nature (see Table 1). Thus, we refer to structural system failures related to the institutional environment, interactions, change and conflict management, as well as transformational failures related to directionality, demand articulation, policy coordination, reflexivity and openness.

Interactions: In all three programs there is a clear ambition to promote new interactions and partnerships across sectors, disciplines and actors. The CDI program involves a broad range of stakeholders in a structured process to formulate priority areas while the SIO and BioNets programs encourage actors from different industries, disciplines and sectors to work together in formulating strategic visions, agendas and roadmaps. Based on initial impressions and evaluations it seems that all three programs indeed have been able to activate new types of interactions and partnerships, even in areas that are relatively established (e.g. the bioeconomy as well as engineering in the case of Sweden). Nonetheless, the programs are so far less explicit in their efforts and approaches to overcome path dependencies and lock-ins in sub-optimal interaction.

Directionality: All three programs exhibit some degree of directionality. The BioNets program is perhaps most directed with its focus on the bio-economy and specific global market opportunities as defined by the strategic agendas in the context of the bioeconomy transition, followed by the CDI program which has identified four priority areas.[5] The SIO program can be argued to be directional in the sense that their strategic agendas identify societal challenges as an overall guiding principle but refrain from pointing out specific challenges. However, while providing some directionality at a rather overarching level (with the exception of BioNets), there is also an emphasis on bottom-up processes in all three programs, within the framework of both societal or grand challenges and market opportunities and industrial renewal (especially in the BioNets program). Thus, the emphasis is clearly on actor-identified and driven areas and initiatives as opposed to top-down steering and priority-setting.

Demand articulation: This is especially evident in the CDI program. The CDI program has a strong focus on involving 'problem owners' and other users or relevant stakeholders – such as municipalities, patient organizations, healthcare providers etc. – as active partners in the projects. According to Vinnova's homepage, "co-creation [between users/customers and providers of solutions] is a critical success factor".[6] The OECD views the orientation towards societal challenges of innovation programs – present particularly in the CDI and SIO programs – as a market creating tool:

[5] The description of possible challenges have, however, only served as guidance and not to exclude other ideas within the broad areas. The crucial aspect of the CDI program is rather to require that some societal challenge should be the starting point for each project, contribution to its solution the objective of the projects and the active engagement of problem owners mandatory.

[6] http://www.vinnova.se/en/Our-acitivities/Cross-borde-co-operation/Challenge-driven-Innovation/Challenge-driven-Innovation/

> *"The 2012 Research and Innovation Bill bases the rationale for an initiative such as the SIO in terms of the generally accepted view that innovation can both underpin the search for solutions to global challenges and create future growth markets in these areas. More specifically, it recognises that interaction and collaboration between diverse sets of innovation actors is key to developing a healthy innovation ecosystem."* (OECD 2016, p.108)

However, aside from the orientation of innovation efforts towards societal challenges, one could argue that market-creating elements – such as innovative public procurement – are not very pronounced in the programs examined, largely because they are beyond the remit of the agencies running the programs. The relevance of demand-side policies, such as public innovative public procurement, for promoting transitions should be highlighted further and become an integrated part of next generation PPP programs.

Elements of **reflexivity and openness** can be found in all three programs. Openness is emphasized by Tekes for the BioNets program even though it is challenging to find a balance between openness and confidentiality in strategic R&D projects of companies. Vinnova also underlines the importance of openness (to new partners) in both its SIO and CDI programs and is currently looking into developing indicators that can measure the degree to which new actors are continuously involved in the SIO programs. Early evaluations and continuous monitoring are integral elements of both the BioNetS and SIO programs, with the expressed intention to enable learning to sustain agility and continuous program adjustment.

Overall, therefore, the new PPPs can be shown to promote new interactions, partnerships and approaches. They have elements of directionality and demand articulation is addressed by emphasizing (and sometime requiring) the involvement of users, customers and/or 'problem owners'. Openness is clearly identified as important and desirable and there is a striving for reflexivity in the form of early evaluation and monitoring which are intended to enable learning and program adjustment. However, it is not yet clear to what extent these new initiatives will achieve the desired outcomes in terms of openness, reflexivity but also in terms of effectively counteracting path dependency and lock-ins to suboptimal interaction. Also, demand articulation in terms of market creating activities, for example in the form of public procurement, are not integral parts of the programs.

A serious challenge shared not only by the three programs exemplified in this paper, but by many other national PPP programs as well, is that they are just that – national. In spite of a general acknowledgement of the global nature of innovation, they often fail effectively to integrate an international or global dimension or element into their programs. In fact, they may introduce a bias in favor of national collaborations or partnerships over international linkages. One reason for this is that it national government agencies often cannot or will not provide funding to international partners. The lack of internationalization was pointed out, for example, in the evaluation of the Finnish SHOKs (Strategic Centers for Science, Technology and Innovation) (Lähteenmäki et al 2013), an earlier high-profile PPP-program model. An evaluation of the first generation of SIO program also reached a similar conclusion (Isaksson and Palmberg 2016).

Furthermore, there are a number of key components of addressing system and especially transformational failures that these exemplified PPP programs do not seem to address. These relate to the **institutional environment** (including regulatory conditions) and other framework conditions, **change and conflict management** (e.g. how to deal with 'incumbents' and the 'losers' of socio-economic transitions), **policy coordination** and governance. In many cases, the absence of elements to address these types of failures can be explained by the fact that the agencies responsible for these programs do not have the tools nor the

mandate to address these issues. Often, they are also beyond the remit of the ministries that these agencies report to. Thus, whereas Tekes and Vinnova are under the authority of the Ministry of Employment and the Economy and the Ministry of Enterprise, respectively, many regulatory and legal changes that might be necessary to enable transformative change (eg. labor laws, competition regulation, product registration regulations, intellectual property laws, state aid rules) fall under the responsibility of other ministries or their agencies

Policy coordination, which requires coordination across ministries, agencies and stakeholders, is especially important for creating niches or spaces for policy experimentation and managing conflicts, including mediation and compensation – between ministries, between regions, between agencies, or more generally between 'winners' and 'losers' of transformative change that might arise as a result of disruptive change. Failures to achieve policy coordination may therefore also inhibit the emergence of new ecosystems that eventually could challenge the current regime and speed up transitions. An interesting example is the bioeconomy, where the experimental use of biomass for new applications often is held back by incumbents, regulations or other barriers. Finally, there are few systemic mechanisms for upscaling successful solutions e.g. in goods and services offered by or provided to the public sectors (e.g. disseminating good practices from one municipality or region to another).

In conclusion, while the design and implementation of the new PPP programs analyzed here reflect a recognition of the need to adapt PPPs to be able to address grand challenges and related global market opportunities, and enable changes in socio-technical regimes, for several reasons, they currently fall short of effectively addressing the issues that our analytical framework highlights as important. This is partially because these new programs and approaches require new or different models, actors and competencies. They also require a form of and room for experimentation and risk-taking that goes against the basic views of how government agencies should operate. But perhaps most importantly, key issues (eg. regulatory changes and upscaling) are beyond the remit of innovation agencies. They require higher-level policy coordination, leadership and political will.

In both Sweden and Finland, a number of initiatives are under way which could address some of these issues, thus complementing the new PPP programs and boosting their role in addressing transitions. These include the launching, or relaunching, of national innovation councils, the Strategic Research Council and the strengthening of analytical and experimental functions at the Prime Minister's Office in Finland, the launching of new test-beds and demonstration facilities in Finland, Innovation Platforms and the Strategic Cooperation Programs in Sweden. However, it is too early to tell whether – together with the new PPP programs – they will be able to tackle the system and transformational failures identified in the literature and respond to market opportunities that grand challenges create globally.

5 Conclusions

In this paper we have shown that advances innovation and transition theory combined with the increasing urgency of societal or grand challenges, and a changing global knowledge and innovation landscape, converge to put new demands on innovation policy instruments. In response, technology and innovation funding agencies are developing new models and programs for public-private partnerships (PPP).

We apply an analytical framework based on system of innovation and transition theory to these new PPP programs to assess to what extent they are likely to be able to address the systemic and transformational

failures identified in the literature. We find that new PPP programs are emerging with clear ambitions both to tackle societal challenges and realize related global market opportunities, as well as drive industrial renewal. Furthermore, some of these programs have clearly expressed ambitions to address systemic and transformational failures. In particular, we see clear elements of promoting new and different interactions, demand articulation, reflexivity and openness and directionality. Regarding the latter, preliminary insights suggest that the programs have new approaches in place to better facilitate emergence and self-organization from the bottom-up, while at the same time encompassing a certain amount of overall directionality (e.g. articulating societal challenges and/or related market needs). This is in contrast with an innovation system approach that has tended to superimpose structures and top-down planning on bottom-up activities. However, an important issue is how a public RDI funder – and by extension, the government - can ensure sufficient control and steering, as well as which types of incentive structures should be created for a good balance between self-organization and policy steering.

We identify two key challenges facing these new PPP programs. Firstly, the new programs and approaches require new competencies, models and actors. Secondly, many of the determinants of whether the PPP programs eventually lead to concrete, competitive and scalable solutions to societal challenges for global markets are beyond the remit of technology and innovation agencies. Ultimately, a key question for policymaking which goes beyond the operations of such agencies is how to enable the creation of spaces for experimentation and learning (e.g. in the sense of unlearning of existing practices) and thus for niches or arenas for new cross-sectoral ecosystems and disruptive innovations. Finally, internationalization still poses a challenge to many national PPP programs due to the national jurisdiction of the agencies that fund the programs.

One conclusion from our attempt to apply an analytical framework to existing programs and practice is that many of the terms identified in theory are revealed as being too 'hazy' to be useful for practical policy and program design. Thus, for example, there is a need to clarify what is meant by directionality, particularly the level and focus of directionality (sector, challenge, policy area, impact logic). The literature also underlines the importance of combining directionality with bottom-up approaches. Here, again, policymaking could benefit from a more ambitious discussion regarding what balance between bottom-up and top-down elements to strive for in designing PPPs. Further, 'reflexivity' is a good objective but it's realization, in turn, depends on the availability of impact logic frameworks and indicators that also apply to transition processes and all the complexities involved. Thus, we find that the world is a little more complex and requires a more nuanced theoretical discussion on issues such as directionality, reflexivity, interactions and openness to be useful to those seeking to design PPPs that might effectively address system and transformational failures.

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