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Policy coordination in systems of innovation: A structural-functional analysis of regional industry support in Sweden

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ABSTRACT

The framework of regional innovation systems highlights the systemic nature of economic development and the importance of coordination of policy activities. Such coordination presupposes an understanding of the underlying problems and how they can be addressed. Generic problems in innovation systems refer to issues of lack of resources, negative lock-in, and structural or functional fragmentation. In spite of this, there are few good examples of systematic analyses of innovation systems that take into account both structural and functional properties of the system. This paper addresses this issue by offering a framework for analyzing innovation system problems, functions, activities, and actors and, based on this, offers insights with regard to the role of regional actors as coordinators of innovation system activities.

Keywords:

Regional innovation systems, innovation policy, systemic problems

Policy coordination in systems of innovation:

A structural-functional analysis of regional industry support in Sweden

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Abstract

The framework of regional innovation systems highlights the systemic nature of economic development and the importance of coordination of policy activities. Such coordination presupposes an understanding of the underlying problems and how they can be addressed. Generic problems in innovation systems refer to issues of lack of resources, negative lock-in, and structural or functional fragmentation. In spite of this, there are few good examples of systematic analyses of innovation systems that take into account both structural and functional properties of the system. This paper addresses this issue by offering a framework for analyzing innovation system problems, functions, activities, and actors and, based on this, offers insights with regard to the role of regional actors as coordinators of innovation system activities.

1. Introduction

When it comes to regional policies for stimulating innovation and innovation-based growth, the innovation system (IS) perspective has, over the last decades, evolved into a popular framework for researchers and policy makers. A reason for its popularity is that it acknowledges the fact that innovation policy should be systemic in the sense that there is a need for coordination between a diversity of activities in order to address relevant problems in an effective way. These activities are performed by different actors in the system. Innovation policy is thus not a task only for public institutions but involve actors from the whole system: firms (the production structure); universities, research institutes, educational and training organizations (the knowledge infrastructure); and public and private networking and policy actors (the support structure). Coordination is required both between actors and activities.

In addition to being systemic, effective regional policy often needs to be tailored to the specific demands of the industrial and regional context. In spite of the practices of many regional initiatives, e.g. to create replica Silicon Valleys, there is no one-size-fits-all policy for promoting innovation in regions (Nauwelaers and Wintjes 2002). The specific preconditions and needs of the region and industry must be considered when designing and executing policy. Different industries (e.g. high/low tech; manufacturing/services; local/global etc.) are faced with different challenges and problems. Furthermore, there are also considerable differences between region types (e.g. peripheral regions; lagging regions; urban regions; clustered regions; fragmented regions etc.). Therefore, designing regional policy requires acknowledging the specificities of the region and its economic structure.

While increasingly popular, the innovation system approach has also attracted criticism for not providing sufficiently practical guidelines for policy makers (e.g. Edquist 2011; Edquist 2005; Klein Woolthuis et al. 2005). This paper addresses the issue of how innovation policy can be "customized" in terms of the activities performed. *Activities* should be designed based on the *functions* they are to perform. The functions, in turn, address specific underlying *problems* in the regional innovation system. The paper proposes a framework for analyzing innovation system problems, functions, and activities and, based on this, offer insights regarding the role of the actors and institutions (e.g. policy) as coordinators of innovation system activities. In doing this, we combine functional and structural analyses of the system in line with the increasing emphasis on the functional patterns of the system rather than solely on its structural properties (Hekkert et al. 2007; Johnson and Jacobsson 2000; Liu and White 2001).

The paper deals with *regional* policy rather than national or sectoral. There is a trend in Sweden and other European countries that the power and mandate to influence are increasingly being shifted from national to regional level (Borrás and Tsagdis 2008). This is not surprising considering the greater autonomy of regional actors to design specialized policy aimed at the regional system. Also, the possibility to influence and work directly with the IS actors is greater in the regional context as compared to national or EU level where influence is more indirect, through formulation of nationwide or even international regulations and support programs. Innovation policy the regional level is important also for another reason. As Boschma (2009 p.5) recognizes, when knowledge spills over between organizations, it tends not to travel over long geographical distances. Given the central role of knowledge development and diffusion for innovation, a regional perspective is thus preferred.

The paper begins with a brief introduction to regional innovation systems (RIS) and regional innovation policy (RIP). This is followed by a presentation of the analytical framework. After that, the empirical study – focusing on three sector specific RIS support programs in Skåne, the southernmost province of Sweden – is presented. Lastly, policy recommendations and conclusions are presented.

2. Innovation systems and IS policy

The concept of innovation systems has been defined on a number of different levels (Carlsson et al. 2002), though these definitions can most often be traced back to seminal contributions by Freeman and Lundvall (see Lundvall 2007 for a historical overview). One early definition is Freeman's: "…systems of innovation are networks of institutions, public or private, whose activities and interactions initiate, import, modify, and diffuse new technologies" (Freeman 1987). Lundvall (1992) further distinguishes between a broad and a narrow view on innovation systems. The narrow definition includes "...organisations and institutions involved in searching and exploring" such as R&D departments and universities. The broad definition, which we adopt in this paper, includes "...all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring" (p.12).

From these definitions it should be clear that an innovation system should not be seen as an actor or an organisational entity; not even necessarily as a group of actors that consciously work towards a common goal. Rather, the regional innovation systems (RIS) approach constitutes an analytical framework that highlights the systemic nature of innovation and innovation policy (Tödtling and Trippl 2005). The actors in an IS can be divided into three stylized categories: (1) the *production structure,* i.e. companies (used as a collective term including both producing and non-producing companies); (2) the *knowledge infrastructure,* i.e. universities, research institutes and training organisations; and (3) the *support structure,* various organisations, often publicly funded, tasked with supporting the economy. These actors are involved in a complex web of formal and informal *networks,* both within and between the subgroups. These network relationships need not necessarily be formalized. Rather the actors should be compatible with each other, thereby constituting a mutually reinforcing system. The *institutional conditions,* both formal (legal etc.) and informal (norms, values etc), provide the "rules of the game" for the way in which interaction and network formation take place (North 1990).

Broadly defined, innovation policy deals with promoting the development, diffusion, and efficient use of new products (e.g. goods and services) and processes and as such follow one of two generic approaches: a laissez-faire or a systemic approach (Lundvall and Borrás 2005). The systemic approach discussed in this paper originates in the contention that most policy fields need to be considered in terms of the extent to which they contribute to innovation (ibid). It is thus not possible to fully understand innovation policy without also considering its workings in relation to other policies like tax policy, education policy, financial policy etc. Following such an approach, the coordinating linkages between parts of the system becomes central. The systemic approach has under the terminology of innovation systems gained much credence in policy circles in Europe at different levels of application: EU, national, regional, and on sectoral or technological levels. Innovation system policy differs from general economic policy as it is

specifically about innovation and it takes a system perspective rather than an actor-centric or laissez-faire perspective (Edquist 1997; Lundvall and Borrás 2005). Viewing innovation as a process taking place in a system of actors rather than within a specific organization (a firm or a university) or a class of actors (firms) significantly influences the way in which innovation policy should be designed to be effective.

In an innovation system context 'policy' is thus to be understood in a broad sense, to include actors representing the support structure from both public and private sectors (Borrás and Tsagdis 2008). Furthermore, policy is to be seen as systemic in the sense that it involves the activities of a multitude of actors and their joint efforts. That is, while policy makers represent a certain class of actors, public and private, that has the role of system facilitators (part of the support structure), policy activities involve actors from all parts of the RIS (production structure, knowledge infrastructure, and support structure). Typically policy activities are coordinated by policy makers (the support structure), but without active participation (both in design and execution) from all RIS actors (representing the knowledge infrastructure, production structure, and support structure) the effects of those policy activities will be strictly limited.

Following this insight, it is clear that the systemic approach inherent to IS theory does not infer that the system can be consciously designed or planned. Similarly to innovation processes, which according to Pavitt (2005) and others are highly contingent, innovation systems evolve in a largely unplanned manner. Therefore, centralized control over the system is claimed impossible. As argued by Edquist (2005 p.191) "innovation policy can only influence the spontaneous development of SIs to a limited extent.". Nonetheless, there is scope for policy influencing the development of innovation systems, but there is no one size fits all approach to designing such policy. Without analyzing the specificities of the system, the regional setting, and the activities, institutions, and actors present in the system, policy will most likely be ineffective (Lundvall and Borrás 2005; Tödtling and Trippl 2005).

3. Analytic framework

The analytical framework presented in this section is based on the combined logics of functional and structural analysis of systems of innovation. The combination of structure (actor-focused) and function (system-focused) is generally seen as a major strength of the IS approach (Edquist 1997). Such approaches have however been largely absent in the literature as most scholars focus on the roles of specific actors or policies on the system (Liu and White 2001). The functional dimension pivots on the trinity of problems, functions, and activities. The sequence in which these are to be addressed is to start with analysis of the problems that exist in the regional system; identification of the functions that need to be filled by policy (by all three type of actors in the system) in order to mitigate these problems; and lastly identification of activities that can be designed and implemented by the actors to perform these functions. The structural component of the analysis focuses on the actors that carry out the activities within the system. Figure 1 provides a schematic overview of the logic of our analytical framework.

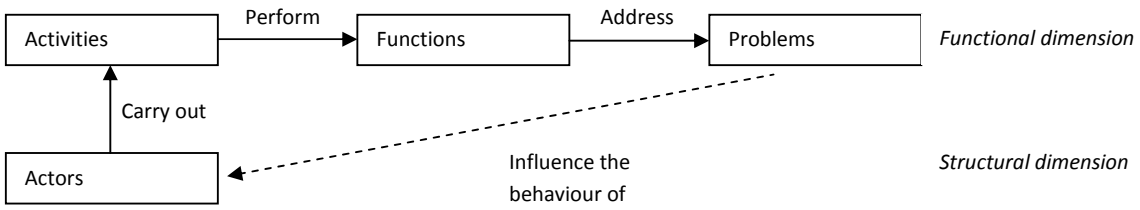

Figure 1: Scheme of the structural and functional dimensions of innovation systems.

3.1 Problems

Understanding the underlying problems and challenges to be addressed is the starting point for innovation system policy. Three generic problems that may hamper innovation activity in regional innovation systems have been proposed in the literature: lack of resources/organisational thinness, fragmentation, and negative lock in (Isaksen 2001; Nauwelaers and Wintjes 2002; Tödtling and Trippl 2005). These problems can be related to both the structural and functional dimensions of innovation systems.

Firms' innovative capacity depends not only on how well they utilize internal resources, but also on their absorptive capacity in processes of open innovation (Chesbrough 2003; Cohen and Levinthal 1990). Thus the availability of relevant resources within the innovation system, coupled with actors' absorptive capacity, is central for the functionality of the system. Lack of resources may be of several types depending on the specificities of the region and industry. In some cases lack of financial resources (e.g. venture capital or seed money) is central while human capital is a more significant problem in others. Lacking R&D or knowledge resources (e.g. scientific knowledge, or more applied skills and capabilities e.g. in marketing or internationalization) may be central in some contexts. Lack of resources is often correlated with the issue of organizational density/thinness within the RIS. Where there is a lack of resources this is often because there is a lack of local actors that supply these resources (directly or through extra-regional linkages). In organizationally thin regions, policy measures should start from an understanding of which specific resources and actors are lacking. Analyzing the RIS components – production structure, knowledge infrastructure, and support structure – is a necessary first step towards such an understanding. The main challenge for the innovation support initiative is then to attract or facilitate the creation of key resources either by influencing regional supply or by stimulating regional actors to meet these needs through linkages to extra-RIS contacts (Isaksen 2001).

Similarly, in fragmented regions, all relevant actors and resources may be present but without forming a working system. For policy to be successful it must be consistent with the incumbent actors' goals and values, and with the resources available within the system. Fragmentation may thus originate in a lack of fit between policy activities and actors' strategies. Such a view corresponds with managerial theories that show that firms that align their strategies and activities with the specific requirements of their environmental context perform significantly better than those that do not (cf. "strategic fit" e.g. Lukas et al. 2001; Venkatraman and Prescott 1990). Furthermore, problems of fragmentation may also be related to the level of interaction within the system and the incumbents' knowledge about the system. Limited interaction and exchange may be due to a lack of trust between the actors (Isaksen 2001). Alternatively it may

be a result of the actors in the RIS simply being unfamiliar with each other and therefore not recognizing potential synergies.

These two types of fragmentation problems are here discussed in terms of institutional versus functional mismatch. They both relate to the problem of fragmentation but the measures to overcome them would differ. *Functional mismatch* is when the functions supported by the support structure of the RIS do not result in mutually reinforcing synergies for the RIS actors. This is often an effect of lacking coordination between the activities in the RIS (Tödtling and Trippl 2005). An example is when knowledge exchange activities aiming to facilitate knowledge development and diffusion in the RIS is performing poorly because of lack of synergies between academia and private companies. *Institutional mismatch* refers to situations when the institutional framework does not fit all actors in the RIS or when there is a lack of trust between the actors. Institutions – the rules of the game/codes of conduct, routines and formal regulations and laws – fill a central role in facilitating trust creation and reducing uncertainty (Tödtling and Kaufmann 1999). Institutional mismatch may be manifested as a lack of collective vision and action amongst the actors.

The third generic problem has to do with positive feedback, path dependency, and lock-in effects (Arthur 1994). This is an inherent problem of innovation systems with a shared institutional setting. Sharing an institutional setting – e.g. laws, rules, and common habits, routines, norms, culture, and established practices – may lead to inertia and lock-in into established ways to do business, approach markets, produce products and utilize technologies (Narula 2002). The strength of internal and external inertial forces on organisations and systems are considerable (Hannan and Freeman 1984). There is thus a risk that, while there may be a functioning RIS in place, the system may be too closed and rigid resulting in institutional, social and cognitive lock-in (Boschma 2005). The risk of negative lock-in is most prevalent in old industrial regions dominated by traditional industries (Isaksen 2001; Tödtling and Trippl 2005) and technologies (Negro et al. 2007). A key issue for the RIS is to facilitate the upgrading and renewal of the knowledge base and ways to do business while at the same time providing stability. In essence to achieve a balance between stability, openness, and flexibility in the institutional structure (Boschma 2005) and in the modes of business and approaches to technology (Arthur 1989). This is sometimes problematic because the industry may experience growth in the short and medium term but may encounter problems in the long run because of lock-in. Gaining acceptance and legitimacy for investments in upgrading the knowledge base and business practices may then be difficult.

As illustrated in Table 1 these generic problems can be expressed along both functional and structural dimensions of the system. Lack of resources has partly to do with organisational thinness (structural dimension) and the collective performance of these actors (functional). Similarly, fragmentation problems can be explained in terms of structural factors (when the institutional framework do not support trust creation leading to low level of interaction) or functional factors (strategic misfit). Lastly, negative lock-in effects may be caused by structural inertia (i.e. the structural and institutional composition of the system) or functional inertia (i.e. the activities and routines within the system).

Table 1: Generic problems in systems of innovation

Problems and Challenges	Functional dimension	Structural dimension
Lack of resources	**Weak performance** The functional dimension of the problem of lack of resources is when there are relevant institutions for supplying the needed resources but when these actors do not function to the best interest of the system. This may be in terms of quality or quantity. It may be the case that the existing organisations do not focus on the output most needed in the system or when the quality of the resources produced is insufficient.	**Organisational thinness** One form of lack of resources originates from organisational thinness, i.e. that there are a insufficient number of actors/organisations that can supply resources needed in the system. One example may be a lack of educational institutions for the supply of skilled labour.
Fragmentation	**Functional mismatch** When the functions supported by the support structure of the RIS do not result in mutually reinforcing action (synergies) for the system as a whole. Such strategic misfit may be an effect of lacking coordination between the activities in the RIS or a lacking understanding of policy maker for the structure and dynamic of the system.	**Structural/institutional mismatch** When the institutional framework do not fit the actors in the RIS resulting in a lack of trust between actors. Also when there the actors in the system is unfamiliar with each other which also leads to limited interaction.
Lock in	**Functional inertia** Lock-in in terms of the activities and functions of the system. This is an inherent problem of systems with a shared institutional setting since that often entails creation of common habits, norms, established practices etc. Thus, the ability to change and adapt the activities performed in the system may be circumscribed.	**Structural inertia** This has to do with lock-in effects originating in the existing structural composition of the system. Existing actors and institutions are subject to structural inertia.

Lastly, it should be noted that these problems are by no means mutually exclusive. A region with an established cluster may experience problems with fragmentation, lock-in, and even organizational thinness. For example, a region with a strong industrial cluster may lack important actors (e.g. may have a strong production structure and support structure but lack an advanced knowledge infrastructure). As a result of this the same region may experience considerable lock-in in established technologies as the knowledge infrastructure needed for technological renewal is lacking. This may also be coupled with an element of fragmentation if the cluster is divided into sub-groups of actors that belong to the same industry or sector but between which interaction and exchange is limited for structural and/or historical reasons.

3.2 Functions

Specifying the underlying problems to be addressed and how they relate to the functional and structural dimensions of the system is necessary in order to understand which activities are to be performed by policy. Prior to designing the specific activities however, there is a need to explicate the functions that these activities are to fill. In the literature on innovation systems an evolving paradigm, particularly within the technological innovation systems (TIS) school of thought, is questioning the value of further analyses of the structure of innovation systems (Liu and White 2001). It is argued that the focus needs to be on key functions (processes) that make the system performing well (Hekkert et al. 2007). At the most general level the main function of an innovation system is to pursue the creation of innovations (Edquist 2005). However, to be useful further specification of the sub functions supporting the main function of innovation systems is required. Johnson and Jacobsson (2000 p.109) developed the concept of 'system functions' and defined it as "a contribution of a single component or a set of components to a system's performance". They argue that an IS can fruitfully be analysed in terms of its 'functional pattern', i.e. how these functions have been served (see also Hekkert and Negro 2009; Negro et al. 2007). Within the literature focusing on the functional analysis of ISs, a number of functions has been identified (see Charminade and Edquist 2006 and; Markard and Truffer 2008 for overviews).

In this paper we build on the inventories of innovation system functions by Berkgek et al. and Hekkert et al. (Bergek et al. 2008a; Bergek et al. 2008b; Hekkert and Negro 2009; Hekkert et al. 2007). These authors identify a number of functions to be performed by actors in the system: Knowledge development and diffusion, Entrepreneurial experimentation, Influence on the direction of search, Market formation, Legitimation, Resource mobilization, and Development of positive externalities/synergies. While these were originally developed for technological innovation systems, they also point to key functions of sectoral subsets of regional innovation systems. Table 2 describes the key functions of RIS as adopted in this paper.

Table 2: Functions of technological innovation systems (adapted based on Bergek et al. 2008b; Hekkert et al. 2007)

Innovation system functions	**Description of function**	**Examples of key output of function**
Knowledge development and diffusion	Creation of knowledge and facilitation of information and knowledge exchange.	Scientific, technological, and market knowledge. Built and disseminated through R&D, learning from new applications, imitation etc.
Entrepreneurship	Creation of new businesses Indirectly: experimenting with new products, identifying and testing new markets and opportunities etc.	Business creation
System infrastructure creation	The development and maintenance of the infrastructure of the system	Physical infrastructure, e.g. production plants, educational institutions etc. Non-physical infrastructure , e.g. educational institutes.
Resource mobilization	Attracting and building resources (human, financial, complementary etc.) relevant to the RIS.	Labour markets (skilled people); financial capital (e.g. venture capital); complementary assets (e.g. support services and products, input goods)

Guidance of search	Induce actors to enter the RIS, to direct their search and investments towards the system. Also to direct the attention of actors in the system towards specific problems and growth opportunities.	Problem and opportunity identification and guide attention of RIS actors to address these
Market identification and formation	Identification of markets or market niches as well as stimulation of the formation of local markets.	Business opportunities identified and demand stimulated/created
Legitimation	Creating/building understanding, support and legitimacy for the RIS activities and agendas (internally and externally).	Internally: Creating coherence, joint vision, shared understanding. Externally: promoting the industry or regional agenda, lobbying etc.
Facilitation/creation of synergies	Stimulate identification and utilization of synergies within the system. Indicates the dynamics of the system since externalities magnify the strength of the other functions.	Collaboration and joint projects (e.g. joint product development, processing, R&D, lobbying, resource development etc.)

These functions of RISs should be seen as ways to address the problems discussed earlier. In a region experiencing negative lock-in tendencies into existing technologies knowledge development and diffusion and entrepreneurship represent functions that may reduce such lock-in tendencies. Similarly, lock-in into specific markets/segments or ways to address markets can be addressed by way of market identification and formation and/or entrepreneurship. While helpful, specifying these functions is however not enough. Policy actors need also to develop concrete activities to perform or promote them.

3.3 Activities

Based on an understanding of key problems and which system functions that address these, it is now possible to identify specific policy activities that can perform or promote these functions. It is widely acknowledged that successful innovation depends not only on the firm's own strategy but also on activities performed by other actors in the innovation system (Cohen and Levinthal 1990; Spencer 2003). These activities can be understood as "policy tools" at the most concrete level. Within a given RIS, a multitude of activities are carried out over varying time horizons. Specifically, many activities such as arranging meetings, courses, lobbying activities, and setting up new system infrastructure involve a limited number of actors and are performed over a limited time. At the same time the aim of these activities are aligned with more long term functions that include many actors in the system. Simply put, any function of the system is achieved through the performance of a number of concrete activities over time (and one activity may contribute to the performance of several system functions) (Markard and Truffer 2008). For example, industry-academia seminars or breakfast meetings may contribute to knowledge diffusion, entrepreneurship, and creating synergies within the system. The function in turn should address one or more of the underlying problems of the RIS. The hierarchy of activities-functions-problems is thus a central avenue for coordination and the activities can be seen as the lower-level determinants of the functional dimension of innovation systems (cf. Edquist 2005).

An important aspect of the systemic approach to innovation policy is that these activities are not performed exclusively by policymakers. IS policy is rather carried out collectively by actors from the knowledge infrastructure (e.g. researchers from local universities participating in

knowledge diffusion or resource mobilization activities), the production structure (e.g. start-up firms contributing to entrepreneurship or market identification and formation), and the support structure (e.g. public bodies that organise innovation policy initiatives to facilitate synergies or legitimation). Having said this, the activities are typically initiated and coordinated by different types of policy actors (public actors, industry organisations, and even innovation system networks etc.). The literature on business development and innovation policy is often vague when it comes to specifying the precise activities that can be undertaken to stimulate change in a particular direction (Borrás and Tsagdis 2008). One reason for this is that activities can be of many types and differ considerably between systems. Since policy activities are specific in nature, they are often designed to address the concerns of a specific class of actors, often a specific sector or industry. Furthermore, a sectoral perspective is often necessary as a basis on which the systems functions and specific problems can be evaluated.

IS policy thus typically involves a multitude of actor-focused and system-focused activities. Actor-focused policy activities include subsidies for research, allocation of venture capital, advice and skills development, incubator activities and education and training. System-focused activities include subsidies for research collaboration, subsidies for infrastructure, network creation/matchmaking, lobbying, marketing/profiling etc. Generally, emphasis is more on behavioural additionality – i.e. persistent changes in the behaviour of the system actors due to the activities performed (Buisseret et al. 1995; Falk 2007; Georghiou and Roessner 2000) – than on resource (re)allocation. Behavioural additionality focuses explicitly on learning and knowledge spillovers that result, both directly and indirectly, from innovation policy (Clarysse et al. 2009).

3.4 Actors and institutions

Attention now turns to the structural dimension of innovation systems, i.e. the actors and institutions comprising the system. To further develop the structural dimension thus far discussed in terms of knowledge infrastructure, support structure, and production structure, a further distinction can be made based on the centrality of the actors in the system. Liu and White (2001) distinguish between primary actors, secondary actors, and institutions. *Primary actors* are those performing fundamental IS functions[1]. *Secondary actors* are organizations that affect the behaviour of or interaction between primary actors (Liu and White 2001). Secondary actors may act *directly*, e.g. when public bodies establish policies and make decisions about sustainability in the public health care system it affects the way hospitals purchase products and services. Alternatively, secondary actors may act *indirectly* through the institutions they create and influence. By for example instituting changes in the tax system, secondary actors indirectly contribute to setting up an institutional system that reward or discourage certain types of behaviour. The interrelatedness between secondary actors and the institutional setting of the IS may thus be considerable.

[1] Liu and White (2001) use the term 'fundamental activities' of an IS. To avoid confusion with our use of the concept 'activities' we apply the term 'functions' here to indicate the more generic nature of Liu and White's 'activities'. Liu and White's classification differs from that presented earlier as their fundamental activities are research, implementation, end use, linkage, and education.

Institutions refer to the sets of common norms, practices, rules or laws that guide and constrain the behaviour of the actors (Edquist 2005; Liu and White 2001). Institutions are thus disembodied organizations that are created, reified, and influenced by the actors in the system. Or as put by North (1992 p.10), "If institutions are the rules of the game, organizations are the players". Institutions can be conceptualized in terms of formal rules (e.g. legislations) and informal constraints (e.g. norms and conventions) (North 1992). Williamson (2000) importantly notes that informal constraints/institutions (what he terms Level 1 institutions) pivot on processes of embeddedness and enculturation that have mainly spontaneous origins (Granovetter 1985). This makes them relatively less affected by deliberative choice and actions than formal institutions (Level 2 institutions) but also subject to an even higher degree of inertia. In the case of innovation systems and policy activities, the formal dimension is clearly relevant in terms of national legislation and regulations as well as industry standards, definitions and guidelines for how sectors are defined (for example the influential ETAP definition of the clean-tech sector). Informal institutions are however equally important for understanding the way ISs work and the degree to which it can be influenced by policy action. In Table 3 Liu and White's typology is illustrated with some examples of actor types.

Table 3: Examples of actors and institutions involved in and influencing regional innovation systems.

Primary actors		**Secondary actors**		**Institutions**
Perform fundamental IS functions		Affect the behaviour of or interaction between primary actors		The set of rules and practices that guide and constrain the behaviour of the actors
Actors	Functions	Actors	Role	
Firms	Entrepreneurship, System infrastructure creation	Public bodies (e.g. Regional authority)	Influence the behaviour of and interaction between primary actors	Laws and regulations Standards and guidelines Business practices
University departments	Knowledge development and diffusion	National government	Influence system and the actors	Norms and convections
Policy actor	Legitimation, Creation of synergies	National and regional bodies, NGOs and other organizations	Influence the system and the actors	

The advantage of applying the primary/secondary actor categories is that they illustrate the different roles taken by IS actors in different situations and in different contexts. The primary/secondary distinction is not a stable dichotomy: i.e. an actor is not inherently primary or secondary. This becomes apparent when relating these roles to the functions discussed earlier. In relation to knowledge development, a university may be a primary actor as it carries out activities central to this function. Firms and policy makers influence the behaviour of the primary actors and the way they interact with other actors; they are thus secondary actors. When it comes to the creation of system infrastructure (e.g. in terms of plants, communication and distribution channels etc.) universities may have the role as secondary actor. In those cases government and firms make out primary actors as they are the ones carrying out the activities (building new processing plants or roads). The location of and the actions taken by local universities can however significantly influence the way in which the activity is carried out.

4. Research design and method

The empirical study in which the analytical framework outlined above was developed and applied is based on triangulation of different methods and data sources. A main input has been in-depth interviews with various types of stakeholders in the system under study. Such stakeholders are firms, universities and public sector organizations (i.e. representing all three parts of the system, filling the roles of both primary and secondary actors). In addition to regionally-based stakeholders, interviews were also conducted with non-regional actors contributing to providing framework conditions to the regional system. VINNOVA, the Swedish Governmental Agency for Innovation Systems, is an example of such actors. The interviews were designed as semi-structured discussions revolving around certain themes which were introduced through questions allowing for open ended answers and elaborations. 21 such interviews were conducted during the course of the research project.

In addition to those interviews, the researchers conducted participant observations in focus group meetings with coordinators of regional innovation support initiatives, both on a regional, national and international level. These meetings gave the researchers access to first-hand information of concrete problems facing policy coordination in real time. Ten such meetings were held during the course of the research project. The third main source of data is based on reviews of previous studies, public reports and websites connected to different actors and activities involved in the regional innovation system of Skåne, including comparative studies and documents dealing with other systems on a national and international level.

Based on these three sources of information, the researchers compiled a data set with information on the structure of the Skåne regional innovation system (i.e. the actors and their relations), the main challenges and bottlenecks hindering the system as a whole to perform well in different respects (the underlying problems), the main activities carried out by different actors in different parts of the system, and the core functions these activities were set to perform or promote. Throughout this data processing, the researchers made efforts to separate rhetoric from actual appearances, thereby critically assessing the effects (functions) of the activities carried out in different parts of the system, as well as the combined effects (intended and unintended) on the system level as a whole.

The following section reports on the main results from these observations, followed by a section analysing them through the lens of the conceptual framework. As introductory stated, the review and analysis has been limited to cover three specific parts of the regional innovation system, representing three different sectors: food, mobile communications and clean-tech. The main reasons for focusing on these sectors and the policy initiatives supporting them are partly that they represent cases to which a large share of regional innovation policy support efforts have been allocated the past decade, and partly that they differ substantially with respect to knowledge base, industry structure, and market orientation. The food sector is targeted by an established regional policy initiative drawing on historical strengths in traditional food production, currently facing challenges for renewal to avoid being locked-in to obsolete technologies. The mobile communications case has some similarities with respect to the industry structure (a number of large anchor firms), however in terms of knowledge base and market orientation there are big differences. These actors are largely science-based and the market focus is ultimately global. The clean-tech case displays differences both with regard to

industry structure, knowledge base and market orientation. This is further touched upon in the next chapter.

There are however also strong overlaps between these three cases since innovation systems always have a generic focus on the entire regional economy and since only few actors (e.g. some firms and specialized support organizations) have a pure sectoral focus (as opposed to e.g. universities and regional governments). To deal with this, both the structural and functional analysis allow for the same actors filling different roles and contributing to different functions in different parts of the system. Furthermore, insights from observations of other sectors in the regional economy are occasionally used for clarification and/or further illustration of some of the core arguments.

5. The regional innovation system in Skåne

Skåne is the southernmost region of Sweden and one of the most densely populated areas in the country. Located across the Sound from the Copenhagen region in Denmark, the majority of Skåne's 1.2 million inhabitants live in the western part of the region. The three largest cities are Malmö (300.000 inhabitants), Helsingborg (130.000), Lund (110.000), all located on the west coast. With a history of heavy industry (ship building, pulp and paper, concrete and stone), food production and processing, shipping and trade, but also some chemical, plastics and textile industries, the region has experienced considerable industrial transition in recent history. As some sectors have almost disappeared (e.g. ship building, textiles, pulp and paper), new ones have emerged. Following the emergence of the knowledge-based economy the main universities in the region (in Lund and Malmö) have played important roles in shaping the current industrial landscape. Industries like pharmaceutical, medical technology, and ICT evolved in the second half of the 20th century in close proximity to Lund University. In addition to this, Lund University played an important role for upgrading established sectors like packaging and food processing. Over the last decade, several new emerging industries and areas of expertise have evolved, not least in conjunction with the growth of Malmö University. Though still relatively small in size, sectors like moving media, computer games, clean tech and sustainability are growing.

The industrial structure of Skåne is quite similar to that of Sweden as a whole. In terms of employees per sector there is a 0.98 correlation between the industry structure in Skåne and Sweden (2007). 17 sectors are found to be significantly overspecialized in terms of number of employees in Skåne as a whole. Unsurprisingly given its historical dominance (Borg 2005), several of these are within food production and processing. Others are machinery production, transportation, medical equipment, and collection and treatment of waste (Henning et al. 2010). As already indicated, the RIS in Skåne is characterized by a strong knowledge infrastructure. Lund University is the largest in Scandinavia with 47.000 students and 6.300 employees. Malmö University, just 20 kilometres from Lund, has an additional 24.000 students and 1.400 staff. Together with other academic environments such as the Swedish Agricultural University outside Malmö and Kristianstad University College they make a strong knowledge and research environment both in terms of knowledge production and dissemination and training of highly skilled labour. Many of the strong industrial sectors in the region are represented by matching knowledge centres at the universities. It is the regional authority, Region Skåne, that coordinates (and co-funds) most secondary actor activities in the RIS.

5.1 Mobile communications, Clean-tech, and Food

The remainder of this paper deals with three sector-specific regional innovation policy initiatives in Skåne. These are Sustainable Business Hub targeting clean-tech, Mobile Heights targeting mobile communications, and Skåne Food Innovation Network targeting the food industry. The initiatives differ in important respects and can be seen as thee distinct cases of innovation system policy. The food case is a traditional industry typically characterised as low-tech and low value added. The sector is coherent and easy to define both when it comes to core (food production and processing) and auxiliary sub-sectors. It is a large sector with a long history in the region and it is characterised by well established firms. The organization which serves as coordinator of the RIS (SFIN) has been in place since the early 1990s.

The mobile communications case is similar to the food case insofar as it is an established and coherent industry with prominent actors in the region. As with food, the industry is quite large both in Skåne and in Sweden as a whole. In contrast to food however, it is characterised as a high-tech and high value added sector. Another difference is that while the food industry comprises a large number of companies (both small and large), the mobile communications industry in Skåne consists of three multinational corporations: ST Ericsson, Sony Ericsson, and Telia Sonera. The two Ericsson companies are both located in Lund and employ about 5000 people. The organization coordinating RIS support for this sector (Mobile Heights) has been in place since mid to late first decade of the 2000s.

Lastly, the clean-tech sector differs from the two above in important ways. Firstly, it is a young sector that is difficult to define with any precision. Clean technology is often defined, based on EU's Environmental Technologies Action Plan (ETAP) as "various activities to highlight environmental technology and environmental technology innovations, as well as to promote demand and improve market conditions" (SWENTEC 2007). This illustrates a central issue of clean-tech, namely that it includes actors from potentially any industry and sector of the economy. While some examples are easily identifiable, for example firms involved in collection and treatment of waste – one of few sectors with significant overspecialization in Skåne – it is difficult to identify general classes of businesses or industries that constitute the clean-tech sector (a conclusion drawn by for example FORA 2009). In the Skåne RIS, firms producing or "implementing" clean-tech are found within areas of water treatment, energy recovery from waste, energy and heating systems (bioenergy, boilers and district heating), energy saving construction and sustainable urban development. Apart from the heterogeneous nature of the sector, it is also quite young in terms of IS policies in Skåne. The IS coordination initiative (SBH) was formed in the mid-late 2000s.

6. Innovation system policies in Skåne: Structural and functional coordination

Innovation policy initiatives in Skåne, as in Sweden as a whole, are often based on a cluster and/or innovation system perspective. This infers both a regional and sectoral perspective and this makes coordination of policy activities a crucial issue. The benefit of a coordinated approach is that it allows a degree of specificity when designing policy activities so that these are customized to the specific needs of the sector and region. As compared to more general cross-sectoral and cross-regional policies it does however, as argued in the conceptual framework section of this paper, require much

more coordination between initiatives, actors and activities. The discussion below analyzes two central aspects of policy coordination: Coordination between policy *activities*, underlying *problems*, and innovation systems *functions* on the one hand and coordination between different (types of) IS *actors* on the other.

Firstly, coordination is required to ensure that the policy activities performed address the underlying problems of the sector in the region. As argued, the general system functions identified in Chapter 3 are achieved by the performance of tangible policy activities by IS actors. Several examples of the importance of coordination between underlying problems, activities, and functions can be given for the cases. All three cases experience problems related to absence of key resources in the system. Such resources are specific skills and competencies (e.g. regarding international marketing and exports in the case of clean-tech) and lack of human capital (e.g. lack of skilled labour in food and mobile communications). Specific activities carried out by IS actors focus on addressing these problems.

The problem of lacking skills and competencies regarding exports and internationalization amongst the firms in the clean-tech sector is addressed by the intermediary organisation Sustainable Business Hub (SBH). This is done by providing services and advice activities regarding business development in the clean-tech sector and help with approaching potential export markets, e.g. by arranging visits to potential markets. These rather specific support activities are related to IS functions, for example to direct the attention of actors in the system towards specific markets, problems, and growth opportunities (market identification and formation; guidance of search). Successful execution of such activities depends on there being actors that can carry out these activities. In the case of clean-tech, lack of resources refer primarily to organisational thinness; i.e. that there are few actors in the system that possess the needed competencies. The IS initiative (SBH) attempts to address this in two ways: (i) by building up their own competence about export markets that can provide advice and support to their members, and (ii) to serve as a link between the firms in the IS and extra-system actors such as the Swedish Trade Council.

When it comes to lack of human resources, which is a problem for both the mobile communications sector and the food sector in Skåne, the problem is functional rather than structural. This means that the system comprises actors that train and educate labour within relevant areas, but they are unable to produce enough output to meet the demand of the actors in the system. A number of activities are performed to address these problems. Both in food and mobile communications the IS-initiatives (SFIN and Mobile Heights) carry out activities aiming at attracting new labour to the sector. In the case of Mobile Heights the focus is on encouraging young people to join the technological programs at the university (mobilization of resources partly through legitimation and supporting the development of the systems infrastructure in terms of educational institutions). This is basically a way to address the problem of the sector that young people today are less attracted by technological university programs than in the past. Even though the large mobile communications companies in the region such as Ericsson (ST Ericsson and Sony Ericsson) and Telia Sonera attract many of the graduates from the universities in the region, the drop in interest in technological training constitutes a growing problem for the industry. The key actors in this are the major mobile communications firms and the Faculty of engineering in Lund.

In the case of the food industry the situation is slightly different. The key issue for the IS initiative (SFIN) is to attract students of for example technology and management to the food sector rather than attracting young people to join specific university programs. This is being addressed by setting up scholarships, promoting the food industry as an attractive industry to enter and having trainee programs involving some of the largest food companies in the region (mobilization of resources and legitimation). The food companies in the region are the key actors for carrying out these activities under the coordination of SFIN. Attracting skilled labour to the industries is a way for both Mobile Heights and SFIN to ensure long term knowledge creation. For both mobile communications and food, the problem is functional rather than structural since the relevant actors are present in the region but they are currently unable to produce a sufficient number of students/attract students to their sector.

A further way to deal with the issue of lack of human capital in the two sectors is by activities designed to facilitate entrepreneurship and creation of new businesses. In mobile communications this is done by setting up incubator activities and in the case of food by direct support (non-financial) for innovations in SMEs (stimulation of entrepreneurship and guidance of search). These activities, though they partly address the problem of lack of human resources, also fill other important functions that address problems of fragmentation and lock-in effects in the RIS. In both mobile communications and food, the IS coordinators (Mobile Heights and SFIN) are the primary actors performing these functions. With support and influence from secondary actors, primarily a number of the key companies in the respective sector.

These examples of how IS-*activities* are based on an analysis of the underlying *problems* of the sector (in the region and in general) and how the activities perform key IS-*functions* illustrate the need for policy coordination. It is also clear that the problems differ by industry. In the case of attracting students to technological university programs and university graduates to the food industry these are general problems for the industries in Sweden as a whole (and in many other similar economies). They are thus not specific to the region. Other problems, such as developing the skills and competencies necessary to identify new business opportunities and new markets within the emerging field of clean-tech are more closely linked to the industry in the specific region. The same is true for generating the necessary skills and knowledge to be able to approach these markets.

A second problem area is that of fragmentation. Fragmentation has to do with the issues of functional and structural mismatch, i.e. when the system functions do not result in synergies (e.g. because of lack of coordination) and when the structural composition and/or institutional framework do not fit the actors in the RIS. In the case of the food sector, functional mismatch was a problem area for the food sector primarily in the 1990s. The RIS comprised a strong knowledge infrastructure within food but there was limited interaction between industry and academia (Kempinsky et al. 2011). Driven by the EU-membership in 1995, the SFIN initiative did however devote considerable effort to this issue and today food is the case with most well developed coordination between activities and the most widely shared vision of the three cases here discussed. Having said this, activities are still performed to address the potential future problem of fragmentation. Chief amongst these are the coordination of a large number of networks (comprising C.E.O.s, researchers, retailers etc.) that directly and indirectly offset fragmentation tendencies.

Networking activities are central not only in food but in all three cases and as in the case of food, these activities are instrumental for reducing the (current or potential) problem of functional and/or institutional mismatch and identify potential synergies between the actors. In clean-tech the issue of fragmentation is particularly evident. This has partly to do with the fact that clean-tech is not an established traditional industry or sector but rather a competence area (FORA 2009). Thus, in the clean-tech RIS the IS coordinator (SBH) is the central actor that work to reduce fragmentation, both structural and functional; primarily through networking activities and by performing the function of legitimation.

The third general problem area discussed here has to do with negative lock-in. This is particularly relevant for the clean-tech and food sectors. In the case of the food industry this relate primarily to the need for renewal and upgrading of a traditionally low-tech industry. This has been a major focus area of the IS coordinator (SFIN) and is thus subject to a number of policy activities. While lock-in effects may be of different types, two important areas for the food industry is technological lock-in (that industry actors become locked into established ways of producing and doing business) and market lock-in (into a dominant view on consumers, consumer behaviour, needs and wants, sales channels etc.). In the case of food, lock-in tendencies are addressed by supporting research (e.g. on food technology, food science, green biotech, consumer and retail studies etc.) and interaction between academia and industry (knowledge development and diffusion). Academia is seen as a source where new approaches and technologies can be identified and by extension new businesses and markets created (stimulation of entrepreneurship and market identification). Another activity to reduce the risk of lock-in is through so called foresight guilds. The IS coordinator (SFIN) organizes thematic meetings and seminars where industry and academia meet and discuss future avenues for development and potential future projects (in addition to the above also guidance of search and creation of synergies). The whole point is to discuss the future development of the industry. Lastly, innovation and start-up support activities (non-financial) is an indirect way to address the problem of lock-in (stimulation of entrepreneurship). By providing help and guidance for new entrepreneurs developing innovative ideas and concepts, the risk of becoming entrenched in existing dominant logics is reduced. These activities involve a multitude of actors. In the case of food in the Skåne system Lund University has had the most prominent role together with the IS coordinator (SFIN).

For the case of clean-tech, activities related to building networks of clean-tech actors and offering business creation and development advice services is a way to help organizations find knowledge-related complementarities and highlight the potential of clean-tech as a means of creating new business opportunities (facilitation of synergies and legitimation). Important issues for the IS coordinator (SBH) is to show ways in which clean-tech can be drawn on to create new business deals, products and services also within existing industries. This is intended to open up for a broader view on what clean-tech means and illustrate how regional firms may benefit from incorporating clean-tech solutions in their existing product and service offering. This is thus much about reducing the risk of lock-in within other industries through the adoption of clean technologies.

This analysis comprises both functional and structural elements, though the focus is on function rather than structure. For each case (clean-tech, mobile communications and food), a further analysis of the structural dimension of the system can also be conducted. This can fruitfully be done by the division into primary and secondary actors. In the three cases here discussed, there is

considerable overlap in terms of actors. This is not surprising as they share the same regional context and thus to a large extent the same RIS.

As has been briefly done above, identification of primary and secondary actors is fruitfully done by case/sector and by function or even by activity. This is because the actors are not inherently primary or secondary but rather their roles as contingent on the activity or function performed. This means that in the mobilisation of resources and knowledge creation and diffusion functions in mobile communications and food, a primary actor is the local universities. They are however influenced by secondary actors in the production structure (e.g. major companies in the system) and in the support structure (e.g. the IS coordinators Mobile Heights and SFIN). In other examples the IS coordinators constitute primary actors; e.g. for market formation and identification within clean-tech where SBH perform this activity themselves. Another example is in guidance of search within food where SFIN is a primary actor when organising foresight guilds. Actors from the knowledge infrastructure and production structure are however also active in performing the activity and should thus also be seen as primary actors.

Even after such a brief analysis of the actors in the system it is evident that there are considerable interdependencies within the system. The secondary actors may in many cases be the same as the primary actors, though they hold different roles in different system settings and functions. The secondary actors are those affecting the behaviour of or interaction between primary actors. From the presentation here it should be clear that coordination does not mean governance or management of the system by for example public bodies and government initiatives. Rather it infers an understanding of which actors and disembodied institutional arrangements are present in the system and what their potential contributions to and influence on different sectors and industries are.

The cases discussed above illustrate the need for coordination between actors, activities, functions, and the underlying problems. The starting point has been the policy activities performed, trying to link them to the functions they perform and the underlying problems that are to be addressed by the functions. The analysis serves the purpose of illustrating the interrelatedness of the structural and functional dimensions of RISs. A similar analysis can of course also be done ex ante by starting from the underlying problems in a RIS in order to identify which functions are needed to address these problems and which activities are most effective for performing these functions. This can then be coupled with a structural analysis of the system; i.e. which actors are present and not present in the systems production structure, knowledge infrastructure and support structure and which roles (primary/secondary) can these actors have in the performance of the activities. And lastly, what is the influence from the institutional setting of the system on the functioning of the system.

7. Conclusions

This paper addresses the issue of policy coordination in systems of innovation from two dimensions: structure and function. Structure and function is, as Markard and Truffer (2008) point out, two intertwined sides of the same object, the system. In the same way as structural factors influence the functions (what the system does and how it works) the functional dimension also influences the development of the structure of the system over time. Analyses of an innovation system's structural

and functional components must therefore be multi-causal and provide scope for interdependent relationships between actors, activities and functions (Edquist 2005). This paper thus relates to the critique against IS research for placing too much emphasis on the actors (actor-centric approach) and not enough on the system as a whole and what actually comes out of the system in terms of dynamics (Edquist 1997; Liu and White 2001).

A systemic functional-structural approach to innovation policy acknowledges the fact that a multitude of actors are involved in activities to promote innovation. Lacking understanding of the underlying problems and the environment in which the system is set, may result in ineffective policy measures. Coordination within the hierarchy of problems, activities, and functions is equally important. Designing policy activities must therefore be related to the IS functions that best address the problems identified and include relevant actors in the system.

There is obviously no generic optimal structure of an innovation system across all industrial and economical contexts (Malerba 2002; Markard and Truffer 2008). This paper outlined a range of specific problems facing different industries in the regional innovation system of Skåne, and analysed how different actors fill different roles in the system, yet acknowledging that the functions they perform and promote in many cases are strongly overlapping. This raises a need for policy coordination, not only of the actors and their respective activities, but also of the broader systemic functions to which these activities collectively contribute. The three sector oriented regional industry support coalitions assessed in the paper deal with policy coordination on the level of actors and activities, while the regional authority (Region Skåne) currently makes attempts to coordinate the broader systemic functions which these support coalitions (and other actors in the region) provide and promote. There is still, however, an empirical question to what extent these efforts of systemic coordination will meet the goal.

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