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A system failure framework for innovation policy design

Rosalinde Klein Woolthuis[a,*], Maureen Lankhuizen[b], Victor Gilsing[c]

[a]Erasmus University Rotterdam and Klein Advies, Amstelkade 144-1, 1078 AV Amsterdam, The Netherlands
[b]EIM Business and Policy Research, The Netherlands
[c]ECIS, Eindhoven Technical University, The Netherlands

Abstract

This article sets out a policy framework for implementing 'system of innovation' (SI)-based strategies. On the basis of a literature review on system failures, the study designs an SI-policy framework that can provide policy makers with practical leads how to design, analyse and evaluate policy measures in the field of innovation. The functioning of the framework is illustrated on the basis of an evaluation of Dutch cluster policy. From this illustration, it can be concluded that the SI-framework provides helpful leads for policy design and evaluation and renders more specific policy recommendations than the generally used market failure approach.

Keywords: Innovation systems; Innovation; Clusters; Policy; Institutions

1. Introduction

In recent years, the system of innovation approach (SI) (see e.g. Edquist et al., 1998) has become more popular, both in the scientific and policy arena. According to the SI approach, innovation is an interactive, non-linear process in which actors, e.g. firms, interact with a manifold of other organisations (e.g. research institutes, customers, authorities, financial organisations) and institutions (e.g. IPR, regulations, culture). This complex process, characterised by reciprocity and feedback mechanisms, determines the success of innovation (e.g. Freeman, 1987, 1988; Lundvall, 1992; Nelson, 1993; Edquist, 1997). By identifying the interactions between actors and institutions, the SI approach uncovers the actors and mechanisms that lead to successful innovation that were left untouched by the market imperfections' approach, thereby offering a greater potential for identifying where public support should go (e.g. which actors to address), and is more helpful for policy makers from a practical and specific point of view (Edquist et al., 1998). By introducing this alternative view on innovation, the SI literature has given way to the identification of new rationales for government intervention, the so-called system failures.

In our view, the current approach still under-exploits its potential for providing practical guidelines and/or rationales for policy makers. This article therefore aims at developing a clear-cut categorisation of failures that can serve as a rationale for innovation policy design. We will illustrate the functioning of such a policy framework by discussing examples of the Dutch cluster policy.

The paper is organised as follows. Section 2 presents a short overview of important contributions to the SI literature. In Section 3, we reframe the system failure framework by distinguishing between actors (players) and rules (institutions). In Section 4, we design a SI-policy framework that enables policy makers to analyse and address systemic failures in their innovation systems (whether they are national, regional or e.g. a cluster). In Sections 5 and 6, we then illustrate the framework on the basis of two cluster initiatives in the Netherlands. Finally, in Section 7, we draw conclusions on the value of the developed framework.

2. Important contributions to the SI literature

The basic conceptual underpinnings of the SI approach are, first, that innovation does not take place in isolation. Interaction is central to the process of innovation, i.e. interaction between actors such as firms, universities,

* Corresponding author. Tel./fax: +31-20-6790383.
E-mail address: rkw@kleinadvies.com (R.K. Woolthuis).

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intermediaries, etc. Central to the concept of interaction are both cooperation and interactive learning (Lundvall, 1992). A second assumption is that institutions are crucial to economic behaviour and performance (Smith, 1997). Legal (e.g. regulation and law) and customarily institutions (e.g. culture and values) form the 'rules of the game' or 'the codes of conduct' that reduce uncertainty in the economic system. These rules shape, and are shaped by, the interactions between actors that take place within these rules. Third, evolutionary processes,[1] play an important role. They generate variety, select across that variety, and produce feedback from the selection process to variation creation (Hauknes and Nordgren, 1999). This process of novelty and variety creation is the result of constant interaction among heterogeneous actors in a population (Smith, 1999) and is necessary to maintain the diversity that makes selection possible (Nelson, 1995; McKelvey, 1997). In all these basic elements, systemic imperfections can occur if the combination of mechanisms is not functioning efficiently. If so, learning and innovation by actors may be blocked by slowing down the innovation system as a whole.

Various authors, including Carlsson and Jacobsson (1997), Smith (1997), Malerba (1997), Johnson and Gregersen (1994), and Edquist et al. (1998), paid attention to these systemic imperfections, leading to the following list of system imperfections:

1. Infrastructural failures (Smith, 1999; Edquist et al., 1998) being the physical infrastructure that actors need to function (such as IT, telecom, and roads) and the science and technology infrastructure.
2. Transition failures (Smith, 1999) being the inability of firms to adapt to new technological developments.
3. Lock-in/path dependency failures (Smith, 1999) being the inability of complete (social) systems to adapt to new technological paradigms. NB: Edquist et al. (1998) address the same failure but do not distinguish so strictly between transition and lock-in failure.
4. Hard institutional failure being failures in the framework of regulation and the general legal system (Smith, 1999). These institutions are specifically created or designed (Edquist et al., 1998) for which reason Johnson and Gregersen (1994) refer to them as formal institutions.
5. Soft institutional failure being failures in the social institutions such as political culture and social values (Smith, 1999; Carlsson and Jacobsson, 1997). These institutions evolve spontaneously (Edquist et al., 1998) for which reason Johnson and Gregersen (1994) refer to them as informal institutions.
6. Strong network failures (Carlsson and Jacobsson, 1997) being the 'blindness' that evolves if actors have close links and as a result miss out on new outside developments.
7. Weak network failures (Carlsson and Jacobsson, 1997) being the lack of linkages between actors as a result of which insufficient use is made of complementarities, interactive learning, and creating new ideas. Malerba (1997) refers to the same phenomenon as dynamic complementarities' failure.
8. Capabilities' failure: Smith (1999) and Malerba (1997) both refer to the phenomenon that firms, especially small firms, may lack the capabilities to learn rapidly and effectively and hence may be locked into existing technologies, thus being unable to jump to new technologies.

Although the picture that emerges from these contributions is fairly consistent with regard to the innovation approach and the issues addressed, there is still some confusion on how the failures should be labelled and be defined in a manner so that the definitions are mutually exclusive. Various authors use different terms for the same or similar concepts, address other elements of the innovation system, or categorise different issues under one heading. To name two examples of these problems: first, where Carlsson and Jacobsson (1997) refer to strong network failure, Smith (1999) and Edquist et al. (1998) do not refer to this type of failure although they do place interaction central to their SI approach. Second, where Smith (1999) uses the concept of institutions for rules and regulations, Carlsson and Jacobsson quite confusingly refer to organisations as (hard) institutions. The authors acknowledge the importance of institutional failure, but unfortunately, the terminology and definitions vary among the contributions. In short, we conclude that because a standard is still lacking in the NIS literature: (1) definitions of the various systemic failures are not yet crystallised out, (2) the same concepts are labelled differently and (3) different concepts (partly) overlap making it hard to distinguish one failure from the other.

3. Reframing the system failure framework

In the literature, helpful leads were found on how more clarity could be achieved in the system failure scheme. Most authors acknowledge that much of the confusion in the SI approach results from its terminology. This, since the term 'institution' is often used to mean 'organisation' in common usage, whereas economists in the institutionalist tradition have a more specific usage—institutions correspond to

[1] Evolutionary processes depend on the following premises: • Bounded rationality of agents—rather than optimising a mathematical function, firms use simple rules of thumb to make investment decisions. • Diversity—rules of thumb differ from one firm to another. • Asymmetric information is a condition for successful innovation rather than being prevented as a market failure, the tool can help to justify the SI-based policy choices regarding what actors and/or failures the chosen policy measures focus on. Without asymmetry, there can neither be novelty nor variety (Hauknes and Nordgren, 1999). • Path dependence—technological progress (learning) is cumulative—the ability of firms to innovate is dependent on what they have been doing in the past (Dosi, 1988).

rules, while organisations are players (Bryant, 1999: p. 73). We found this distinction between rules and players (a point also made by Edquist et al. (1998) and North (1991)) to be a crucial distinction to enable the definition of mutually exclusive system failures and the design of an SI-approach-based policy framework. If the distinction between rules and players is translated into the policy arena, one can define the players/actors as the policy makers, firms, universities, etc. that actually 'act' to make policy objectives happen. The rules/institutions can be translated into the outcomes of their actions, e.g. legal offices write law (hard/formal institutions), companies together form a cooperative culture (soft institutions), universities and firms form R&D alliances (interaction), etc. It is mainly in the 'rules' category, that system failures occur. IPR regimes may be too strict or cultures too risk averse to enable innovation (institutional failure), or firms may fail to interact properly (network failure). Only if essential organisations are lacking in the system, system failure occurs on the 'actor's side'. For example, if regulatory bodies are absent, firms will miss these laws in e.g. safeguarding their intellectual property rights in the innovation process. Other examples of missing actors might be venture capitalists, insufficient innovative buyers (lack of lead users), or the absence of research institutes for applied knowledge. This will be referred to as 'missing actors' and will not be regarded as systemic failures on the 'rules' side' although the actors by being absent can cause systemic failure (Edquist, 2001).

By clearly keeping the distinction between actors and the rules which are most related to the system failures, the system failure framework can be reorganised in a way that the definitions of failures exclude one another. This categorisation is not claimed to be 'the one solution' that will set the standard for future discussions on the SI approach and system failures. It is intended to become a practical tool for both researchers and policy makers to:

- *analyse* where system failures occur, e.g. what kind of failure occurs, what actors—or interactions between them—are hindered,
- *justify* SI-based policy choices that actors or failures focus on,
- *evaluate* current government policies, e.g. do they address the right failures/actors or are there other or more important ones that form the bottleneck in the system.

The newly configured framework is presented in Fig. 1 and the rationales for restructuring the framework such as this will shortly be addressed afterwards.

The categories presented above are structured in a way that we can distinguish between

- actors, i.e. customers, firms, policy departments, research institutes, consultants etc. that act and thereby cocreate not only products and technologies but also the institutional framework in which they function. Because of the aim of our paper, we place policy makers in a central role and see the other's as actors they can interact with in designing, implementing and evaluating innovation policies.
- rules/system failures, i.e. the conditions that are either specifically created by the actors, or have spontaneously evolved, that influence not only the functioning of individual actors, but also the system as a whole.

By making this distinction, the system failures are positioned on the left-hand side, whereas the actors that can cause, and thus also solve these failures are on the top. Because of this distinction between actors and failures, it also becomes possible to make a clearer distinction between cause and effect in terms of system functioning and outcomes. For instance, weak network failure may occur when companies do not interact efficiently; this may be a lack of cooperation with market parties, with technologically complementary firms or e.g. with the knowledge infrastructure (the actors). Furthermore, the attentive reader will notice that in the framework, no use is made of lock-in and

Actors (missing actors) / *Rules (system failures)*	**Demand** •Consumers •Large buyers	**Companies** •Large firms •MNCs •SMEs •Start-ups	**Knowledge institutes** •Universities •Technology institutes	**'Third parties'** •Banks, VCs •Intermediaries, consultants •Sector organisations, employers
Infrastructural failure: ICT, roads, railroads, telecom, ..				
Institutional failure:				
• Hard: laws, regulations, …				
• Soft: norms, values, …				
Interaction failure				
• Weak network failure				
• Strong network failure				
Capabilities failure				

Fig. 1. The SI-policy framework.

path-dependency whereas these are clearly central concept in the SI approach. This is because these phenomena are considered a result rather than a cause of systemic failure. Lock-in can be the result of e.g. very few weak ties to bridge structural holes (strong network failure), lack of complementary cooperative relationships (weak network failure) or a simple lack of technological and organisational capabilities within the firms themselves (capability failure). Lock-in thereby refers to a complex composition of causes: not only does it concern the shift to a new single technology but it also acknowledges the interconnectedness of that technology with its social and economic environment. "This means that technological alternatives must not only compete with components of an existing technology, but with the overall system in which it is embedded. Technological regimes or paradigms persist because they are a complex of scientific knowledge, engineering practices, process technologies, infrastructure, product characteristics, skills and procedures which make up the totality of a technology and which are exceptionally difficult to change in their entirety." (Smith, 1999: p. 44).

Since innovation policy is generally aimed at stimulating technological progress, and lock-in can be considered as stopping progress at the systems level (and as a result of the failures mentioned in the scheme above), SI-based innovation policy could be redefined as the process of identifying the causes of lock-in and eliminating those bottlenecks to enable innovation and economic progress both at the firm and system level. The uncovering of causes seems to be a good way forward to identify the (mix of) objects (actors/failures) that policy makers should focus on in this process.

4. System failures in the SI-policy framework

On the basis of our literature review and the reframing of the system failure framework along the lines of actors and rules/failures, we have arrived at the following conceptualisation of the system failures. The categorisation aims at providing a detailed description of causes, thereby making it possible to analyse where bottlenecks exist and to design policy measures accordingly.

4.1. Infrastructural failures

Issues regarding the physical infrastructure in the relation with innovation have received relatively limited attention by innovation scholars. However, for companies to succeed, they need a reliable infrastructure to enable their everyday operations and support their long-term developments. Especially, the knowledge infrastructure and a high-quality ICT infrastructure are emphasised in the field of innovation. Smith (1999) and Edquist et al. (1998) differentiate the following elements:

- Communication and energy: high-speed ICT infrastructure, broadband, telephone, energy supply, etc.
- Science–technology infrastructure: availability of scientific and applied knowledge and skills, testing facilities, possibilities for knowledge transfer, patents, training, education etc.[2]

We would like to emphasise the importance of the additional infrastructure, accommodation and transport. Smooth roads, reliable railroads, adequate offices, laboratory space, science parks, etc. form a basic condition for an economy to flourish.

In general, the above-mentioned infrastructure is characterised by its very large scale, indivisibilities, and a very long time horizon of operation. Because of this, it is highly unlikely to produce adequate returns (ROI) for private parties to invest in them (Smith, 1999). This explains why the government has a responsibility in addressing such infrastructural needs and preventing failures from occurring.

4.2. Institutional failures

All authors distinguish institutional failures. This should come as no surprise, since institutions form a key factor in systems theory that envisages the institutional context as a defining and structuring element in the system. The authors do not agree though on how to frame and define the different forms of failure. Whereas Carlsson and Jacobsson (1997) refer to hard- and soft institutional failure, Edquist et al. (1998) refer to consciously created vs. spontaneously evolved institutions, and Johnson and Gregersen (1994) distinguish between formal and informal institutions. Although differently named, there is a clear consensus that there are 'hard' institutions, being the formal, written, consciously created institutions, and the 'soft' institutions which are informal, have often evolved spontaneously and may be the implicit 'rules of the game' (North, 1991). Both may regulate economic behaviour and interaction, and can thereby stimulate or hinder innovation. Taken together, these institutions are conceptualised as the selection environment in which firms, knowledge institutes as well as the government itself are embedded. As a result, we can distinguish between hard- and soft institutional failures. We will elaborate on these failures below.

[2] Smith (1999) not only speaks of the presence of such infrastructure, but also draws attention to the interaction with the above-mentioned infrastructure. In this paper, we strictly distinguish between the actors (knowledge institutes, companies, etc.) and the systemic failures which hinder or support these actors. In this manner of modelling, the knowledge institute is considered an actor, whereas the infrastructure it provides (knowledge, possibilities for knowledge transfer, or interaction) is called a system characteristic (or failure).

4.2.1. Hard institutional failures

Hard institutional failures refer to the formal institutional mechanisms that may hinder innovation. These may be a part of the framework of regulation which consists of (Smith, 1999):

- technical standards, labour law, risk management rules, health and safety regulations, etc. and,
- the general legal system relating to contracts, employment, IPR within which the actors (not only firms, but also knowledge institutes and e.g. the government) operate.

These laws and regulations are often not only at the national level, but increasingly also at the supranational level (EU). Examples are international anti-trust regulations, accounting rules, and health and safety regulations. It also includes the legal system relating to e.g. contracts and employment, IPR, etc. Particularly important for innovation are IPR, since they enable actors to appropriate the benefits of innovation, and the system of corporate governance (Edquist et al., 1998). For innovation to be successful, the system of corporate governance should allow the management to invest in tangible and intangible assets upon which innovation depends. Short-term planning horizons, risk averseness and strong emphasis on short pay back periods for investments (driven by the 'share holder's value' paradigm) will likely hinder successful innovation. Because of the importance of IPR, Malerba (1997) refers to hard institutional failures as the appropriability conditions: a too stringent appropriability regime may greatly limit the diffusion of advanced technological knowledge and eventually block the development of differentiated technological capabilities within an industry. This is defined as the appropriability trap.

4.2.2. Soft institutional failures

Whereas the hard institutional failures refer to the formal, written laws and regulations, the soft institutional failures find their source in the wider context of political culture and social values, which shapes public policy objectives, the macroeconomic policy environment (Smith, 1999) and the way 'business is done'. These soft or informal institutional failures include social norms and values, culture, the willingness to share resources with other actors (Saxenian, 1994), the entrepreneurial spirit within organisations, industries, regions or countries (Carlsson and Jacobsson, 1997), tendencies to trust (Fukuyama, 1995), risk averseness etc. These institutions form the implicit rules of the game that can stimulate or hinder innovation.

4.3. Interaction failure

A basic premise of the systems approaches is that markets characterised by atomic, one-shot buyers and sellers do actually not exist. Rather, market relationships "persist through time and involve inter-firm cooperation in the development and design of products" (Smith, 1999: p. 21). Hence, the links, interactions and cooperative relationships between the actors in the NIS are a central element to the analysis. These interactions not only involve relationships with other firms, but also the interaction with e.g. the government, public knowledge institutes, and third parties such as specialised consultants. Interaction failures can evolve in two ways: there can either be too much or too little interaction, strangely enough leading to the same sort of systemic failure.

Carlsson and Jacobsson (1997) distinguish between weak- and strong network failures, that arise in situations in which interaction is too weak (little of no interaction) or too strong (too much interaction). Both strong- and weak network failure can hamper innovation. In the elaboration below, we have added insights from the fields of interorganisational relationships, strategic alliances and sociology.

4.3.1. Strong network failure

Intensive cooperation between actors can be very productive as a source of synergy, complementary know-how, creative problem solving, capacity sharing, etc. (e.g. Rothwell, 1989, 1992; Contractor and Lorange, 1988). However, strong cooperative relationships among an established group of actors also imply risks. Carlsson and Jacobsson (1997) describe the situation of strong network failure as one in which individual actors are guided by other network actors in the 'wrong direction' and consequently fail to supply each other with the required knowledge. This is caused by a lack of information exchanges with actors who perform a bridging role, i.e. who tap into new knowledge, question existing routines, etc. This may potentially block renewal from outside. We add the following causes for strong network failure:

4.3.1.1. Myopia due to internal orientation. If the network or cooperative relationships are long established and trust relationships and habituation has occurred, they can become characterised by a certain degree of closure (Bogenrieder and Nooteboom, 2002). The group will be reluctant to exit the group, or let new entrants in. Within the group, 'group think' may lead to myopia and inertia (Nooteboom, 2000), i.e. parties will mainly focus on themselves and on what they do well. As a result, insufficient attention is paid to developments outside, and the firms may be locked into existing (technological) trajectories. Successful networks (hot spots) may then well develop into unsuccessful ones (blind spots) due to their ignorance of relevant developments outside (Pouder and St. John, 1996). In the literature, this is also referred to as overembeddedness (Granovetter, 1985) and social liability (Leenders and Gabbay, 1999).

4.3.1.2. Lack of weak ties. The strong tie argument was initially set on the agenda by Granovetter (1983).

He discussed the value of weak ties in breaking through a too strong internal orientation. Weak ties are the 'bridges' to relative strangers from e.g. different industries, and different educational or cultural backgrounds. Because of their relative distance to the 'inner circle', they have not become a part of e.g. the group think as described above. The works of Granovetter (1983) and Burt (1987) emphasise the importance of these relationships because these form the weak links to new knowledge and impulses or span the structural holes (Burt, 1987) of knowledge that the individual firm lacks. They plea for a portfolio of external linkages with external parties to keep up to date with new developments and keep tabs on new knowledge, skills and resources.

4.3.1.3. Dependence on dominant partners. Whereas the above two points merely refer to the internal vs. external focus of actors, dependence refers to the ability of partners to switch to alternative partners or ways of doing things. Actors may be 'locked into' their relationships due to asset specificity, switching costs or due to a lack of alternative partners in e.g. high-tech or highly monopolised markets (Williamson, 1985).

4.3.2. Weak network failure

Effective innovation is increasingly the result of close interaction between complementary technologies and actors. When the connectivity among these elements is poor, fruitful cycles of learning and innovation may be prevented. Carlsson and Jacobsson (1997) refer to this as weak network failures. This is consistent with Malerba's (1997) concept of dynamic complementarity failure. Complementarity may concern knowledge, skills, know-how and capacity. As a result of weak network failures, possibilities for interactive learning and innovation are under-utilised and firms may fail to adapt to new technological developments. Moreover, if organisations in a system interact poorly, this may lead to a lack of shared vision of future technology developments, which in turn might hinder the coordination of research efforts and investment (Carlsson and Jacobsson, 1997).

Both strong- and weak network failures can in their own manner hinder successful innovation.

4.4. Capabilities' failure

Whereas strong- and weak network failures can lead to e.g. lock-in, the lack of effective and efficient interaction is certainly not the only cause for this. Companies can also simply lack the competences, capacity, or e.g. resources. We refer to this failure as capabilities' failure. Central to the argument is that firms are unable to make the leap from an old to a new technology or paradigm. To be able to make such a leap, firms need capabilities such as flexibility, learning potential, and resources to adapt to new technologies and market demands and be able to survive. Even if they can tap into these resources though interfirm relationships (interaction), they will only get access to these resources if they have something to offer in return. Therefore, the individual strength and development potential of a firm are of crucial importance. Smith (1999) has signalled problems with regard to this as he observed that firms often have problems adapting to new technologies and markets. This is because "Firms almost always concentrate on what they know best: they focus on products and technologies where they have experience and skills" (Smith 1999: p. 43). This specialised focus enables them to 'do their thing right', but can seriously hinder the firm's development if the required capabilities to adapt to new technologies, lie outside a company's existing capabilities. This is even more the case if a shift is needed into a completely new technological paradigm. This will entail adaptation to completely new generic technologies, which require capabilities (which are usually not only technical but also organisational) lying outside the existing structure of capabilities. Especially for SMEs, with limited resources and staff, this might prove difficult. Smith (1999) has labelled this type of failure as 'transition failure'. Malerba (1997) discusses the same phenomenon under the heading of 'learning failure' which he describes as that firms or industries may be prevented from learning rapidly and effectively which might lead to lock-in into existing (technological) trajectories.

5. Using the SI-policy framework

The systemic failures as presented cannot be addressed directly, or by one actor alone. If policy makers want to use the framework, they will have to address groups of actors to make changes in the innovation system possible. By using the framework as a tool for analysis, policy makers can identify: (1) where systemic failures occur (e.g. a lack of entrepreneurial spirit hinders innovation), and (2) which actors should be addressed to make change possible (e.g. promote an entrepreneurial spirit at knowledge institutes, provide venture capital). Most problems in the innovation system will not be uni-dimensional but will consist of a complex mixture of causes and effects, and involve several actors. By using the framework, priorities can be given to the most stringent obstacles for innovation and thus also serve as a guideline to implement innovation policy. Lastly, the framework can be used as a tool for evaluation of (already implemented) policy programmes. By first analysing where the major bottlenecks were located in the innovation system, and then evaluating where the policy actions focussed on, one can evaluate the extent to which the policy measures addressed the right systemic failures and actors. One can then link the success of the policy measures to the 'fit' between the SI-framework analysis and actual measures to find whether the SI-framework can explain 'ex-post' whether the approach taken was the most suitable

one. In short, this framework provides added value to policy makers in three distinct ways:

- It points to those elements of an innovation system in which failures can occur and as such forms a basis for policy choices that actors or failures to focus on.
- It points to the fact that policy measures should be different with distinct types of systemic failure.
- It enables to evaluate such policies: to answer the question whether the right failures have been addressed and how the effectiveness of policy differs for each type of failure.

Since the SI-framework has not been used yet for policy planning, we will illustrate the framework in the next section by evaluating two cluster policy projects of the Dutch government. This to show how the framework might work and help policy makers to derive specific policy recommendations from the framework. The Dutch cluster policy was chosen since this policy is designed at the system level, involves all actors (firms, knowledge institutes, policy makers), and the clusters are mostly aimed at either taking away the bottleneck to enable innovation, or at becoming leaders in a new technological field.

6. An illustration of the SI-policy framework: two projects from the Dutch cluster programme (1994–2002)

In the early 1990s, the Netherlands decided, as one of the first countries, to adopt a cluster perspective as part of its innovation policy. Inspired by Michael Porter's 'Competitive Advantage of Nations' (1990), the Netherlands has been among the first to change its industrial, sector-based policy approach into a cluster-based approach. Starting as a novel concept, numerous cluster studies followed in order to make clusters more transparent, both to firms as to policy makers. In 1993, the 'Industry Paper' as well as the policy paper 'Competing with Knowledge' further elaborated on the newly developed notions by focussing on the importance of cooperation, both between firms as with the public knowledge infrastructure. The 1995 'Knowledge in Action' paper further set out the points of innovation-oriented policy in greater detail and addressed the importance of a close connection between public and private research. Simultaneously, various R&D subsidy-schemes were developed. Whereas the original focus of these schemes was on the stimulation of cooperation between firms, they were later broadened towards stimulating technological cooperation within clusters. In 1997, a further refinement has taken place as three policy roles have become more specifically defined:

- *Strategic information*: A cluster crosses sector boundaries which makes it not always easy to understand its (changing) structure. Therefore, the government can try to create a better insight by providing strategic information. Often, this information will be generated by close interaction and information exchange between policy makers, firms and knowledge institutes. Such information may cover a wide range of topics ranging from new market developments, technological changes, other forms of cooperation, non-technological innovations, the impact of internet, etc.
- *Organising capacity*: In addition to information, the government can also become involved by means of its organising capacity. Firms in a cluster may need a sort of 'process manager' who is capable of facilitating cooperation between firms. Due to the boundary crossing nature of clusters, firms may not always be familiar enough with each other in which case the government may act as a neutral mediator. Examples of relevant instruments are among others brokerage events, conferences and platforms. The instruments of strategic information and organising capacity are aimed at specific clusters.
- *Subsidies*: In addition to the above mentioned tools, subsidy-schemes are also available which provide an incentive for R&D in cooperation with another firm or (public) research institutes. This is a more generic instrument.

The rationale of subsidies relates to the old neo-classical argument of market imperfections with its potential for under-investment in R&D and linear approach to innovation. In contrast with subsidies, the instruments related to cluster policy, such as the provision of strategic information and organising capacity, do not find their rationale in market failure. The rationales for these government interventions are loosely linked to the interactive model of innovation and the systems approach as found in the NIS literature.

6.1. Evaluation of Dutch cluster policy

In an extensive study including 12 cluster projects that were implemented as part of the Dutch cluster policy over a period of around 8 years time (1994–2002), we tested the SI-framework. We selected two projects, that greatly differed both in their successfulness and the extent to which they were executed in line with the SI-framework, to illustrate the framework. The study made use of a case study methodology. Interviews were held with policy makers, as well as with project leaders and participants. For the case studies, 7–10 semi-structured interviews were held. The interviews included questions on the major bottlenecks which the parties perceived with regard to their industry and the innovation system in which they operated. Second, the interviewees were asked whether the project addressed the right issues, involved all relevant parties and whether they considered the project and the cluster approach to be a success. We complemented the interviews with the study of all project documentation, including roadmaps of

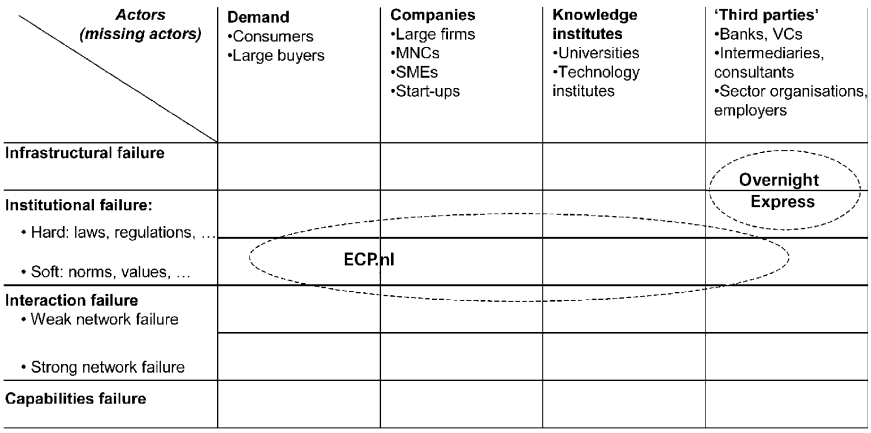

Fig. 2. The observed system failures.

the industry, business plans and project evaluations. Taken together, these sources made it possible to develop a solid understanding of what the projects have entailed.

In Fig. 2, a short overview is given of the bottlenecks of two industries/clusters as they were experienced by our respondents. We plotted these bottlenecks using the SI-framework: the circles represent the areas in which system failures are observed and the actors that are related to causing and/or potentially solving these failures.

In the next section, we will describe the projects by first addressing these bottlenecks. Second, we discuss how the projects have been executed, i.e. analyse which bottlenecks were actually addressed by a project (which failures are addressed by which actors). Last, we confront the perceived bottlenecks when using the SI-policy framework, with the bottlenecks that were actually addressed. We hypothesise that a project that is executed in congruence with the SI-policy framework will be more successful in actually solving bottlenecks and achieving success.

6.2. ECP.nl—developing the institutions necessary for e-implementation

With the upcoming applications of ICT since 1990 such as electronic data interchange (EDI) and e-banking, new institutions had to be developed to facilitate and enable efficient and reliable exchange of information (compatibility of system software, trusted third parties). Potential ICT users were largely unaware of the full range of applications of ICT, distrusted the exchange of (personal) information over the internet and lacked confidence in e-commerce in general. Hence, there was a lot to be done in providing information and especially in building trust with professional users and consumers. To facilitate a swift adoption of e-commerce in the Netherlands and to improve the competitiveness of the Dutch e-business cluster, a project called E-commerce Platform Nederland (ECP.nl) was started. The aim of the platform ECP.nl was to bring together all the relevant parties in order to jointly solve some of the fundamental issues in this area.

When we take the SI-framework as our analytical tool, we can observe that these fundamental issues refer to systemic failures for the e-cluster, especially hard- and soft institutional failures. Hard institutions form a problem in the sense that standards and appropriate legislation are still lacking. Actors need these institutions to be able to exchange data in an efficient and reliable manner. Soft institutional failure entails the belief among professional users and consumers that e-business is unreliable in terms of performance and safety (privacy). No single actor can solve these systemic failures i.e. set a standard for data exchange or create consumer trust. The institutional failures can only be solved by involving many actors. Consumers have to become aware of the possibilities and be given the confidence that they can safely adopt e-applications. Companies have a role to play in raising both the awareness and trust, and in increasing their willingness to make the investments required to boost e-commerce. Universities and knowledge institutes have a role to play if it comes to developing new applications, providing specialist knowledge on e.g. juridical issues or sketching scenarios for the future. Finally, third parties (with a special emphasis on the government) have an important role to play when it comes to regulations and e.g. IT infrastructure. In short, the SI-policy framework would suggest a policy approach that involves lead customers, companies, knowledge institutes, specialist third parties and the government to create the soft- (trust, confidence) and hard institutional conditions (standards, legislation) that enable the system to shift to a new technological paradigm in which e-applications play an important role.

Based on the evaluation of which actors were involved and which failures were addressed, we conclude that the project did exactly what the SI-framework suggested. In the project, all actors mentioned worked together in creating the hard- and soft institutions necessary for the adoption of e-commerce by companies and consumers. The established platform grew from 30 organisations at the start to around 200 in 2002. The actors participated in the platform's activities which consisted of specialist workgroups,

workshops for knowledge transfer, discussion meetings, etc. The common aim of the actors was to accelerate the development and use of e-commerce by way of providing information, raising awareness, standardisation, creating codes of conduct, etc. that are useful for all. This provided a fruitful ground for cooperation. The joint efforts led to the development of a standard that has meanwhile been adopted by the UN. The ECP.nl project has become a very successful platform, leading to positive reactions even outside the Netherlands.

To sum up, the ECP.nl case has shown to be an informative illustration of how the SI-framework may be used to lead to policy recommendations and how actual policy actions can be analysed and evaluated based upon the framework. With the benefit of hindsight, we can conclude that the project has remarkably well adhered to the actions that the matrix would also suggest if it had been used prior to the project's start. We might carefully suggest that the success of the project can at least partially be explained by the fact that the project has addressed the right issues with the appropriate mix of actors.

6.3. Overnight Express—a fast train to substitute congesting roads

The export of fresh fruits, flowers and vegetables are an important factor in the Dutch economy. Because the products are susceptible to decay, their transportation has to be fast and reliable. International road transport is becoming increasingly expensive due to legislation and less reliable due to increasing congestion. To create a secure, frequent, in-time and fast alternative for road transportation to the important export region of Northern Italy, the project "Overnight Express" was initiated. The project's aim was to bring shippers of fresh products (flowers, fruit and vegetables) and rail transport companies together to set up a high-quality rail connection between Amsterdam and Milan. If the project were successful, the Overnight Express to Milan would serve as an example to demonstrate the viability and potential of rail connection for the future (which was also desirable because of both safety and environmental reasons).

When using the SI-framework to analyse the bottlenecks that parties face, it can be concluded that road transport is increasingly problematic and that a shift to a new 'transport paradigm' is desirable. However, rail transport is also not without problems. There are large regulatory and technical differences across countries that complicate rail transport across national borders. Due to these differences, trains have to wait at national borders, suffer from extensive paperwork, have to change to national locomotives, and as result can only move very slowly (around 60 km/h). A further complicating factor is the fact that national passenger trains always have priority over commodity trains. This decreases both the speed and reliability of international commodity trains. In terms of the SI-framework, the bottlenecks mainly lie in the lack of standardisation and coordination between the European Member States i.e. in the hard institutional failure sphere. If the European Member States would have clear-cut joint approaches in their rail transport system, more intensive use could be made of freight trains (as in the US). The framework would suggest addressing the bottlenecks by involving rail companies, lead customers that would like to use rail transport for their goods, and regulatory bodies (national government, the European Commission). Because of the international character of the project, these actors should reside in the relevant countries (the Netherlands, Italy and the countries through which the train passes on its way).

The actual approach chosen by the Overnight Express project shows limited analogy with the suggestions as derived from the SI-framework. Although the framework suggested that the primary bottleneck lay in the institutional failure domain, and a solution should hence be sought in changing the international hard institutions (e.g. by lobby work, international committees), the project took a very different approach. The project leader aimed at establishing closer cooperation between a group of Dutch companies among which were growers, transport companies, the National Freight Railways and large retailers. Although all parties supported the project and acknowledged the importance of a reliable transport alternative, the project was not successful. Whereas first technical problems delayed the project's start, the train ran into the expected institutional delays as soon as the technical problems were solved and the train was actually trying to transport the goods to Italy. Regulations (e.g. with regard to the coupling of passenger trains with freight trains) considerably reduced the maximum speed of the train, making it an unattractive alternative to road transport. The cooperation between the companies came under great pressure. It was not long before the first companies withdrew from the project, and after 1.5 years, the project was unsuccessfully terminated.

In sum, we conclude that the project did not tackle the systemic failures as pointed out by the SI-framework, nor did it involve the relevant actors to address these failures. Although the intentions and aims of the actors involved were right, a project limited to national cooperation on a technical level (by developing the more sophisticated fresh freight train) could never have solved the institutional bottlenecks in the regulatory sphere. The project should have adopted a broader focus, i.e. it should have included a wider set of actors including (international rail) authorities, and it should have been more aimed at removing the bottleneck in the institutional framework, i.e. the regulation pertaining to international rail transport. The wide gap between the observed bottlenecks and the way in which the project was actually implemented is illustrated in Fig. 3.

We carefully suggest that the project would have been more successful if the policy actions had focussed more on the bottlenecks as indicated by the SI-policy framework.

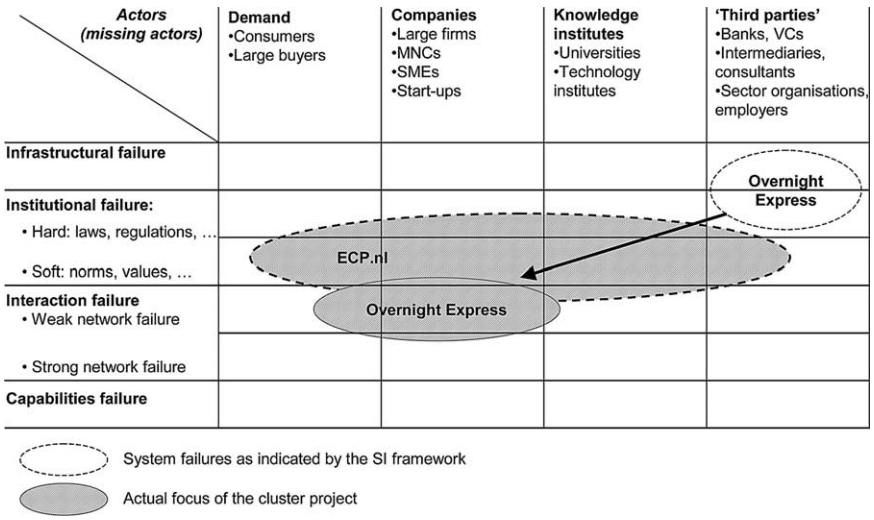

Fig. 3. The observed vs. the actually addressed system failures.

Our framework might furthermore provide a helpful tool to understand why the Overnight Express project has not been successful.

6.4. Analysis

If we compare the two projects that we chose to illustrate the functioning of the SI-policy framework, we see that the framework proves to be a valuable instrument for determining where exactly the bottlenecks lie and how they are addressed (which actors and failures). A graphic representation of the cases is given in Fig. 3. In the figure, the area in which systemic bottlenecks were observed is indicated with a white circle, whereas the grey circles now represent the area on which the project focussed in reality.

In the ECP.nl project, the project's execution was to a large extent congruent with the actions that would have been recommended on the basis of the SI-framework. The project was highly successful. One might cynically conclude that obviously the SI-framework is not needed to design and implement successful innovation policy. However, we would like to argue that the ex-post observation that the framework can help in analysing the problems and hence might help in explaining why the ECP.nl was so successful, illustrates the usefulness of the framework.

The Overnight Express project is an example where the observed, and the actually addressed system failures/actors widely diverge. The project was unsuccessfully terminated. Although we cannot draw conclusions on the basis of only two cases, they do carefully suggest that the framework does provide leads for understanding why one project is more successful than another.

7. Conclusion and discussion

This paper aimed at designing a policy framework based on the system of innovation approach because, in our view, the current approach still under-exploits its potential to provide practical guidelines and/or rationales for policy makers. Based on a review of the SI-literature, a framework was designed that enables a clear-cut distinction between the different forms of system failures, and the actors that should be involved to address these failures. This enables policy makers to analyse, evaluate and design policy measures, especially in the field of innovation. The functioning of the framework was illustrated by evaluating recent cluster projects by the Dutch Ministry of Economic Affairs.

We conclude that the framework provides us with a tool to analyse policy actions and both evaluate and explain the success of these actions with the SI-policy framework as a point of reference. In this respect, the SI-framework proves to be a more practical guideline for policy design than the market failure framework. The recommendations that can be derived from the framework can be very specific about which systemic failures should be addressed and which actors are key to solving the bottlenecks. Policy measures can be implemented by involving those actors that can solve the bottleneck.

The framework could still be improved and extended. Our review of the system failure literature has not been completed, neither did we include all system failures that we found in the existing literature since some system failures are in a too abstract level of analysis to 'fit into' a straight forward logical frame. Such was the case for Malerba's (1997) distinction of selection/adaptation and exploration/exploitation failures. Furthermore, the illustration of the framework on the basis of two cases is not sufficient to draw conclusions on the value and usefulness of reframing the system failures and designing the framework. This calls for further study, whereas the framework could further be tested in practice by using it as a tool to analyse system failure and design and evaluate innovation policy measures.

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Rosalinde Klein Woolthuis is a business research associate at the Erasmus University in Rotterdam and a free-lance consultant in the field of economic policy and innovation. She obtained a Ph.D. on her research on high-tech interorganisational relationships and worked as a consultant for Technopolis in the field in cluster- and innovation policy for several years. Research interests include interorganisational relationships, trust, innovation and their role in economic development.

Maureen Lankhuizen works as senior consultant for the Dutch Economic Centre for Small and Medium Sized Enterprises. Before that she worked as a consultant for Technopolis, an international research and consulting organisation focussing on science, technology and innovation policy. Her Ph.D. thesis (MERIT/University of Maastricht) deals with the problems associated with the internationalisation of innovation systems in Eastern Europe. Part of her research was conducted at the World Bank in Washington, DC. Research interests include international comparisons of national systems of innovation, science policy, and innovation in SMEs.

Victor Gilsing works as assistant professor at the Technical University Eindhoven and received his Ph.D. degree from the Rotterdam School of Management. His thesis deals with sectoral innovation patterns and interfirm networks. Research interests include evolutionary theories on innovation and cluster development. He worked for more than 5 years at the Dutch Ministry of Economic Affairs in the field of innovation policy and before that worked for Unilever where he held several international positions in the field of innovation and business-to-business marketing.