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Application of an integrated systemic framework for analysing agricultural innovation systems and informing innovation policies: Comparing the Dutch and Scottish agrifood sectors

Chrysa Lamprinopoulou [a,*], Alan Renwick [b], Laurens Klerkx [c], Frans Hermans [c], Dirk Roep [d]

[a] Land Economy and Environment Research Group, Scotland's Rural College – SRUC, UK
[b] School of Agriculture & Food Science, University College Dublin, Ireland
[c] Knowledge, Technology and Innovation Group, Wageningen University, The Netherlands
[d] Rural Sociology Group, Wageningen University, The Netherlands

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ABSTRACT

Innovation is receiving increased attention among policymakers as a means of addressing sustainable economic development challenges. However, a range of factors such as inappropriate physical and knowledge infrastructures, incoherence of institutional frameworks, or lack of specific capabilities may have a negative impact on the functioning of the agricultural innovation system. The purpose of this paper is to apply a comprehensive innovation systems analytical framework, reconciling analyses of systemic structures, functions, failures and merits of innovation systems to assess and compare the performance of the agricultural innovation systems of Scotland and the Netherlands. To achieve this an analytical framework was drawn up based on the available literature, and through a process that included document analysis and a series of semi-structured interviews and workshops with experts in the two countries the agrifood sectors were empirically assessed. In both countries, systemic failures in terms of actors' interactions and competencies as well as market and incentive structures were revealed. However, differences emerge between the two countries that appear to relate more to social and cultural (soft institutions) differences rather than the formal legal and regulatory frameworks (hard institutions).

1. Introduction

Innovation and knowledge exchange are receiving increased attention among policy makers as a means to develop an economy capable of mitigating climate change, whilst responding to the pressures arising from a growing demand for food, increasing energy-costs and resource scarcity (European Commission, 2011). Recently, the agricultural innovation systems (AIS) approach has been recognised amongst researchers and policy makers as a promising tool to understand and support processes underlying innovation, knowledge exchange and transformation of agricultural and food sectors (Klerkx et al., 2010; Ortiz et al., 2013; Spielman et al., 2008). Beyond primary production, the AIS approach comprises the innovation activities of the broader agrifood complex along the full value chain. The strength of this approach is derived from rejecting the simplistic 'linear' or 'pipeline' model of technological knowledge transfer from research through extension services to farmers (Clark, 2002). The AIS approach recognises that innovation is the outcome of an interactive and co-evolutionary process (Smits and Kuhlmann, 2004), where a wider network of actors are engaged, with the speed and direction of innovation processes affected by the institutional and policy environment (Hall et al., 2006; Hermans et al., 2013b; Klerkx et al., 2010). Consequently, innovation combines not only technological but also social, organisational, economic and institutional changes (Klerkx et al., 2012; World Bank, 2006). In line with this systemic approach to innovation, a need emerges for the development of analytical tools and policy instruments that diagnose and enhance the functionality of the whole system as an entity, rather than on its specific components (i.e. particular actors or institutions – Wieczorek and Hekkert, 2012), offering a better insight into coordination and alignment of system components.

The literature in the agricultural innovation domain is rich in empirical studies using the innovation systems approach at different levels (e.g. national, regional, sectoral, technological – see e.g. Klerkx et al., 2010; Pascucci and De-Magistris, 2011; Klerkx and Nettle, 2013), but relatively few studies apply a comprehensive

* Corresponding author. Tel.: +44 (0)1315354182.
E-mail address: Chrysa.Lamprinopoulou@sruc.ac.uk (C. Lamprinopoulou).

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and whole systems analysis as has emerged in 'mainstream' innovation systems studies. Such a whole innovation systems analysis gives insights in enablers of innovation, it can conversely also highlight problems or imperfections innovation systems, and comprehensive frameworks have also been proposed to assess systemic failures and merits (Klein-Woolthuis et al., 2005; van Mierlo et al., 2010; Wieczorek and Hekkert, 2012). However, with a few exceptions (Amankwah et al., 2012; Gildemacher et al., 2009; Ortiz et al., 2013) the most recent frameworks for whole systems analysis based on in the innovation systems theoretical framework have not been empirically applied to the analysis of AIS. Here, especially the functional analytical approach is a novel feature (following a review by Klerkx et al., 2012). This paper aims to address this gap, by undertaking a comparative comprehensive system analysis of the Dutch and Scottish agrifood sectors.

Building on classifications of innovation system structures, functions and systemic failures found in literature (Bergek et al., 2008; Hekkert et al., 2007; Klein-Woolthuis et al., 2005; Wieczorek and Hekkert, 2012), we combine several analytical tools into an integrated framework aiming to assess performance of innovation systems and to formulate related policy recommendations. What this paper adds is that it discusses which dynamics exist between all key structures and functions of innovation systems, and which policy instruments may affect these dynamics in a way that transform systemic failures into merits. The key aims of this paper are hence to:

(i) identify amongst the existing innovation systems frameworks the analytical building blocks necessary to holistically describe and investigate an AIS;
(ii) operationalise and combine these building blocks into an integrated analytical framework;
(iii) apply the integrated analytical framework in the context of the Scottish and Dutch agrifood sectors with the aim of revealing from the informants viewpoint where particular strengths and weaknesses exist as regards innovation and what are the underlying reasons for this,
(iv) inform innovation systems policies.

The paper is organised as follows. In Section 2, the integrated analytical framework is presented, clarifying the particular analytical tools which are used to describe the dynamics and performance of the Scottish and Dutch agricultural innovation systems. Section 3 describes the methods used. Section 4 focuses on presenting the results of the cross–country comparison. Here then follows discussion of the implications of the findings for theory and policy in Section 6, before the paper ends with some concluding remarks.

2. Towards the development of an integrated analytical framework

2.1. Structures: actors and institutions in innovation systems

To classify key innovation agents in each of the two national AIS Arnold and Bell's (2001) typology of actors in innovation systems is typically applied, which reflects broader frameworks for analysing social-ecological systems (Ostrom, 2009). This typology classifies actors into four broad categories (domains), namely, research, enterprise domain and more distant actors influencing innovation (indirect demand domain/innovation influencers domain), and an intermediary domain. More specifically, the research domain typically includes universities and research institutes or private R&D departments (e.g. from companies or NGOs) producing basic or applied research and primarily codified knowledge. The enterprise domain involves the supply chain actors i.e. input suppliers, farmers, food manufactures or retailers who typically use codified and tacit knowledge, and produce tacit knowledge. The indirect demand domain includes a group of more distant actors influencing and impacted by innovation, including final consumers, policy-makers, social interest groups (e.g. charities and NGOs) and markets complementary to the agrifood sector such as energy or pharmaceutical markets. Finally, the intermediary domain in innovation systems considers organisations that may not necessarily be involved in knowledge creation or usage, but are playing a catalytic role in joining fragmented IS actors and facilitating knowledge/innovation flows. These organisations typically are education and extension services, levy or trade industry boards, consulting services or pure innovation brokers whose primary task is building bridges between knowledge providers and users. The above categories (domains) are not mutually exclusive, due to the multiple roles that actors can play and the fact that these roles evolve over time (World Bank, 2006). Typically, roles of actors and interactions between actors are shaped through infrastructures (e.g. research infrastructure, physical infrastructure (roads) and communications infrastructure). Besides the actors, interactions and infrastructures, structures in innovation systems are also considered to contemplate the institutions that govern their behaviour and influence the interactions and relationships among actors (Hall et al., 2006; Wieczorek and Hekkert, 2012): these include formal rules and regulations (laws, intellectual property rights) and informal rules (normes, values, incentives).

2.2. Adding functional analysis to enrich structural analysis

Functional analysis emerged to complement the structural focus with a process-oriented analysis, identifying different functions of an IS, i.e. the collective and aggregated outcome of basic innovation 'activities' that innovation actors are engaged in (such as funding research, knowledge creation etc.), and assessing the performance of the system on whether or not all the functions are being performed properly (Bergek et al., 2008; Hekkert et al., 2007). The analysis of functions reveals the state of an IS at a defined moment in time (Wieczorek and Hekkert, 2012). It has been argued however that neither of these two separately-developed approaches (structural and functional) alone constitute a sufficient basis for analysis of ISs (Bergek et al., 2008). For example, Wieczorek and Hekkert (2012) explain that structures make functions meaningful and vice versa, and argue that alteration of a structural element is always necessary for policies to enable or strengthen functions. Hence, an integrated structural–functional analysis provides a much more comprehensive overview of the operation of systems and the determinants that shape innovation trajectories (Bergek et al., 2008; Wieczorek and Hekkert, 2012).

An illustration of how the coupled structural–functional approach works is provided by Wieczorek and Hekkert (2012), where each system function is seen through structural elements, namely actors, institutions, infrastructures and interactions within the IS, whose absence signifies a systemic structural failure. Based on combining insights from Hekkert et al. (2007) and Bergek et al. (2008), eight functions/processes were identified as important for innovation systems to perform well, (see Fig. 1). These functions, which should be present in well-functioning innovation systems, consecutively or simultaneously, include: F1 – knowledge development (either through research or learning-by-doing); F2 – entrepreneurial activities/commercial experimentation; F3 – knowledge diffusion/exchange in networks; F4 – funding, F5 – mobilising non-monetary resources (e.g. in-kind contributions, supply human capital), F6 – market formation (i.e. commercialisation of innovative products/services); F7 – guidance of the search (i.e. identifying problems, recognising the potential for change,

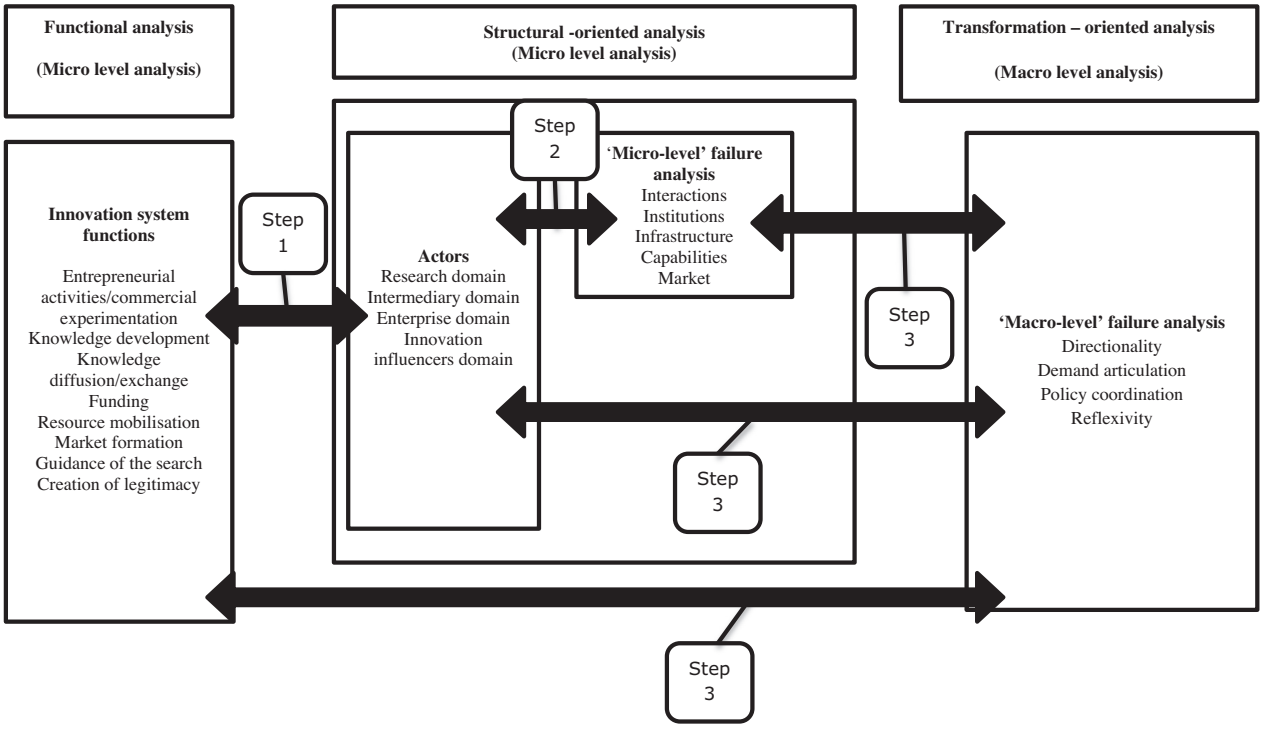

Fig. 1. Integrated framework – conceptual level.

and showing the direction of search for new technologies, markets, partners); F8 – creation of legitimacy (i.e. counteract resistance to change and legitimate technologies). Mapping the functions, and the interaction between them, are expected to inform policy by identifying 'motors of innovation', i.e. sets of functions that reinforce each other and accelerate developments, as well as lacking functions which hinder innovation (Hekkert et al., 2007).

2.3. Analysing how structures enable or disable innovation system functions by means of detecting 'system failures'

Originally, as suggested by its name, structural analysis served to study structural elements of innovation systems, including the actors, institutions (in terms of the 'rules of the game') and infrastructures (Smith, 1997). Within structural analysis, there has been a focus on identifying failures within innovation systems and different classifications of these systemic failures can be found in the literature. These are alternatively called systemic problems, weaknesses or blocking mechanisms (Jacobsson and Johnson, 2000). Within this context various authors (Klein-Woolthuis et al., 2005; van Mierlo et al., 2010; Weber and Rohracher, 2012) propose an innovation system failure matrix. This places different actors against systemic failure categories. The initial work by Klein-Woolthuis et al. (2005) listed four categories, namely infrastructure (physical, knowledge and financial), institutions (formal/hard and informal/soft), interactions and capabilities. van Mierlo et al. (2010) extended the matrix, by introducing the concept of market structure failure. Weber and Rohracher (2012) advanced Klein Woolthuis et al.'s work further and considered the policy framework's potential to deal with the strategic challenges of transformative change in innovation systems towards a desirable direction, i.e. how the whole innovation system, and not only sub-sections of the system adapt to emerging challenges. They added four additional potential failures: directionality; policy coordination; demand articulation and; reflexivity.

The different categories of innovation system failures are the following (Klein-Woolthuis et al., 2005; van Mierlo et al., 2010; Weber and Rohracher, 2012; Klerkx et al., 2012):

- Infrastructural failures concern (absence of) the physical infrastructure, such as railroads telecom, machines, buildings, harbours etc. are constraints requiring major investments that cannot be made independently by the actors of the system. They also concern investments in knowledge infrastructure (e.g. R&D facilities, libraries, training systems, knowledge, expertise, know-how and strategic information), and financial infrastructure (e.g. subsidies, grants, incentives from banks etc.).
- Institutional failure refers to either laws, regulations and strategies any other formalised rules (the so-called 'hard institutions'), or a set of unwritten rules, common habits, routines and shared norms/values used by humans in repetitive situations i.e. 'the way business is done' (the co-called 'soft institutions'), that are missing or 'malfunction', hampering innovation. Related to interaction failures at either a network level or bilateral contacts between individuals is the so-called 'strong network failure', which refers to actors locked into their relationship, which causes myopia, blocks new ideas from outside and prohibits other potentially fruitful collaborations. This is an interaction intensity type of problem, whilst the so-called 'weak network failure' constitutes an interaction presence type of problem (Wieczorek and Hekkert, 2012). The latter refers to a situation where actors are not well connected and fruitful cycles of learning and innovation may be prevented because there is no creative recombination of knowledge and resources. These two failures indicate an apparent paradox in networking for innovation: a quest for a balance between openness and closure, informal or formalised interaction, trust relationships or contracts (Håkansson and Ford, 2002).
- Capabilities failure points to actors' "capacity to learn, innovate or utilise available resources; to identify and articulate their needs; and to develop visions and strategies" (Wieczorek and

Hekkert, 2012, p. 79), that falls short of what is required or expected. It also encompasses insufficient networking or negotiation skills, and organisational capacity of actors to adapt to and manage technological and organisational innovations.

- Market structure failures refer to the positions of and relations between market parties. Such as a monopoly or the lack of transparency in the ever enlarging food chains, but also imperfections in the 'knowledge market' (Klerkx and Leeuwis, 2008).
- Directionality failure implies that socio-techical transformational change is closely linked to direction and the setting of collective priorities for the system, referring to the lack of shared vision, and inability of collective coordination of fragmented change agents due to the effect of power on defining any vision (Weber and Rohracher, 2012).
- Policy coordination failure refers to coordination and coherence problems at policy levels e.g. regional-national-European or technological versus sectoral innovation policies.
- Demand articulation failure "reflects a deficit in anticipating and learning about user needs...(and is addressed through) joint learning processes involving producers...(and) innovation-oriented procurement mechanisms to directly stimulate the advancement of novel solutions from the demand side and users" (Weber and Rohracher, 2012, p. 1043).
- Finally, reflexivity failure concerns the insufficient ability of the system to engage actors in a self-governance process, to constantly monitor progress against the transformational goals, and finally to anticipate and develop an adaptation strategy (e.g. stop policy initiatives if proved less promising than initially expected, Weber and Rohracher, 2012).

While the failure analysis has a focus on where systems do not function, as van Mierlo et al. (2010) and Klerkx et al. (2012) note, at the same time it can also be used to highlight innovation systems merits in the respective categories.

2.4. Towards an integrated framework

Fig. 1 illustrates the proposed integrated framework emerging from the combination of the two complementary tools of Weber and Rohracher (2012) and Wieczorek and Hekkert (2012) at a conceptual level.

Fig. 1 highlights that the link between the analytical blocks identified above is provided by the concept of 'actors' which mediate between functions and structural or transformational failures. As shown in Fig. 1, within a successful innovation system, individual actors are engaged in innovation 'activities', which contribute to the overall innovation system functions, and for which different actors will play different roles (Hermans et al., 2013a). In order to fulfill their roles, actors, who represent a core structural element of innovation systems, form, develop, constitute and deploy a range of other *basic* structural elements of the innovation system including institutions, interactions, infrastructures, market structures and capabilities. It has been proposed that assessment of these basic structural elements can be used to examine under-performance of functions by actors using the failures as analytical focus points (Bergek et al., 2008; Hekkert et al., 2007 and lead to mechanisms for alignment and coordination (Wieczorek and Hekkert, 2012).

Beyond this level, analysis needs also to examine functioning of the entire system at its most aggregated form, whether it fulfils collective innovation priorities, and if not, what prevents processes of transformative change towards the desirable direction. Moreover, Weber and Rohracher (2012) first recognised even if functions are seen through structural elements, conventional systemic and market structural failures have inherent limitations of being "confined to addressing structural deficits in innovation systems" (p. 1042), and serving just the narrow scope of innovation performance. Furthermore, these authors called for a new approach that serves a broader scope, namely the strategic and long-term needs of goal-oriented transformative change occurring in innovation systems. This transformation-oriented approach is alternatively called 'positive external-economies functioning", in contrast to 'internal functioning' that coincides with the traditional structurally-oriented approaches.

The failures analysis thus distinguishes between a micro (narrow) and a macro (broad) level of analysis of innovation system functioning. The micro level of analysis includes the aforementioned assessment of how failures may affect individual actors contribution to fulfilling the innovation systems functions (see Fig. 1), and the impact of structural and market failures. The macro level of analysis of failures comprises all the parts and aspects of an innovation system as a whole entity, and primarily investigates if its basic structural elements and functions performed through actions at the micro level are sufficiently coordinated, aligned and harmonised with each. This follows the idea of so-called *transformational* failures by Weber and Rohracher (2012) which represent the overall functioning of an innovation system and its capability to renew itself and support major transitions in agricultural systems (as opposed to incremental improvement of existing systems). In the macro perspective, an AIS is then seen as a nested set of 'systems within systems' (Hekkert et al., 2007), and 'innovation is both an individual and a collective act' (Edquist, 2001). This also indicates an apparent paradox in the AIS functioning, that the degree of coordination and alignment of basic structural elements and functions can be sufficient to fulfil the innovation goals of single actors (micro view), but not necessarily support the collective priorities of the entire system in its most aggregate form (macro view).

3. Case selection and research methods

3.1. Case selection

The Dutch and Scottish comparison is useful for a number of reasons, as there are some differences and similarities. First, there are perceptions that the Dutch have one of the most innovative agrifood sectors in Europe and therefore can provide a useful 'benchmark' against which to evaluate Scotland. Recent evidence (van Galen et al., 2013) highlights that the Netherlands (NL) are near the top of innovation league (number three, behind Denmark and Germany) whilst the UK (including Scotland) is much lower down. Second, as both countries are EU members they have the obligation to comply with common EU agricultural, environmental and innovation policies. Therefore, a comparison between the Scottish and Dutch AIS allows alternative approaches to addressing common regulatory needs to be explored (e.g. ways of providing financial support for innovation within the constraint of EU state aid rules). Third, both countries followed the logic of liberalisation and embarked on a process of privatisation of extension services and research establishments from the 1980s which led to a proliferation of new knowledge creators and providers. This competition means that both countries face a need to establish strong intermediary brokerage structures to connect demand and supply in the agricultural knowledge market, and offering extra incentives to stimulate interactions and collaboration between innovation stakeholders (European Commission, 2011). Therefore it is useful to compare the alternative approaches to achieving this. For instance, the comparison becomes particularly relevant due to findings suggesting that the Dutch government, in contrast with the Scottish government, sees no role to intervene in the market

processes and correct inefficiencies related to innovation (European Commission, 2011).

3.2. Methods

The data was collected during the years 2012 and 2013, with primary data derived from interviews and workshops in each country. In the Netherlands, 11 interviews were held with key informants and one facilitated workshop was held with 11 participants to do a collective system analysis (following van Mierlo et al., 2013). In Scotland, 23 interviews and a workshop with 20 participants were held to support data collection. Arnold and Bell's (2001) typology of actors in innovation systems (domains) was an analytical tool to identify important organisations and actors to include in interviews and workshops, so included researchers, consultants, retailers, representatives of farmer unions, levy boards, governmental agencies and intermediary organisations. The informants and workshop participants were selected on the basis of:

- their knowledge/insight in the Scottish/Dutch agricultural innovation landscape;
- their ability to articulate their opinion;
- their influence/power within their organisation and in the wider agricultural innovation landscape (opinion leaders), and
- the position of their organisation in the innovation system as recognised by other informants.

For each country, to ensure the inclusion and representativeness of all major different perspectives/viewpoints in the agrifood IS, and the key organisations or leading individuals, the research team re-evaluate and accordingly adjusted the list of selected informants, for either interviews or workshops, separately with each chosen informant. So, the final outcome was a list including informants whose knowledge, ability, influence and key position were re-cognised/evaluated by more than one of their peers – insiders to the system, rather the researcher team (an outsider). Particular emphasis was placed on instilling a sense of importance/responsibility in informants for their choices (of other informants) and that their answers should accurately reflect the reality of the agrifood IS under investigation to their best knowledge, with polyphony and conflicting viewpoints fully respected, and desirable to capture.

Diagnostic questions based on the analytical framework were used to assess how the different actors in the innovation system contribute to certain innovation system functions, and how the presence, necessity and quality of structural elements affects the performance of in the innovation system (Carlsson et al., 2002; see Fig. 2 and Tables 1 and 2). Diagnostic questions about the presence, necessity, efficiency and effectiveness provide a basis for evaluating mechanisms for coordination, alignment and harmonisation (integration) of structural elements at the macro-level. For example, if policies are coordinated and visions are aligned, then an innovation system would not suffer from a *policy coordination failure* and a *directionality failure* respectively.

The analytical framework was hence translated into semi-structured interview and workshop discussion guides were, serving as a 'checklist' of all crucial analytical elements (Patton, 1990). Semi-structured discussion guides leave room for open questions for informants to express their own experiences and decision making processes in their own words (McCracken, 1988). Overall, they were deemed appropriated on the basis of offering both some flexibility and consistency across counties to collect enough data of good quality to fill the proposed matrices (see Tables 1 and 2). For example, although the focus was primarily kept at national level, informants were allowed to use examples of sub-agrifood sectors, or specific technologies to illustrate their arguments, and make the discussion more precise and meaningful. As all assessments with regards to performance made in this study are based on the informants' perceptions, with the researchers addressed the risk of informants holding back information or purposefully overreacting to certain issues, by demanding the respondents to fully justify and give examples on either positive or negative statements as regards innovation system performance. Key informants were requested to assess performance against their own expectations, beliefs on which and how actors should perform functions, and the innovation needs of their organisations. Furthermore, triangulation was done with available literature, such as policy documents and scientific articles. As well as detailed document analysis, the workshops with participants different from interviewees enable validation and enrichment of informant interview data.

3.3. Data analysis

The research team in each country analysed the qualitative data, through an iterative process of attaching codes through steps 1, 2 and 3 of the analysis (Corbin and Strauss, 2008), connected to the integrated framework used in the study (Fig. 2). The final outcome, a coherent story, underpinned by diverse informants' viewpoints, was composed by the researchers through comparison and integration. This analysis per country was exchanged between the two research teams to achieve similar levels of understanding and a degree of triangulation on interpretation of results, by stimulating questions for further analysis of why differences were observed between countries. Due to the expected lack of knowledge of the other country in the comparison done in this article, informants were not asked directly to compare the Dutch and Scottish AIS. However, the exchange of information on analysis between the research teams allows to develop a sense of a relative degree of satisfaction (or dissatisfaction) of informants actors with IS performance in each country, based on the intensity of positive comments and complaints made.

4. Findings

For ease of exposition, the analysis broadly follows the structures derived from the analytical framework. First, and overview of actors is given and the results related to functional performance are considered before the analysis of systemic failures and merits.

4.1. Contribution of actors to fulfilling innovation system functions

Table 3 summarises the types of actors identified within each domain, the IS functions that they are associated with and some perceived areas of under-performance, from the key informants' perspective. These are discussed in more detail below.

Within Scotland the universities and research institutes are perceived to perform well in terms of *knowledge development*; however, they are viewed as underperforming those functions which involve exploitation of that knowledge (e.g. *knowledge diffusion/transfer*). Whilst it was identified by informants that farmers and indigenous firms (often SMEs) should play an important role in *knowledge development* it was perceived that they lacked involvement in this area. In contrast, larger (often externally-owned) input suppliers and some innovation-orientated multiple retailers are seen as effective in contributing to fulfilling many key functions (such as *knowledge development*, *commercial experimentation*, *guidance of the search*, *resource mobilisation*, *funding*, and *creation of legitimacy*) therefore playing a key role in the innovation system. Though it should be noted that they face

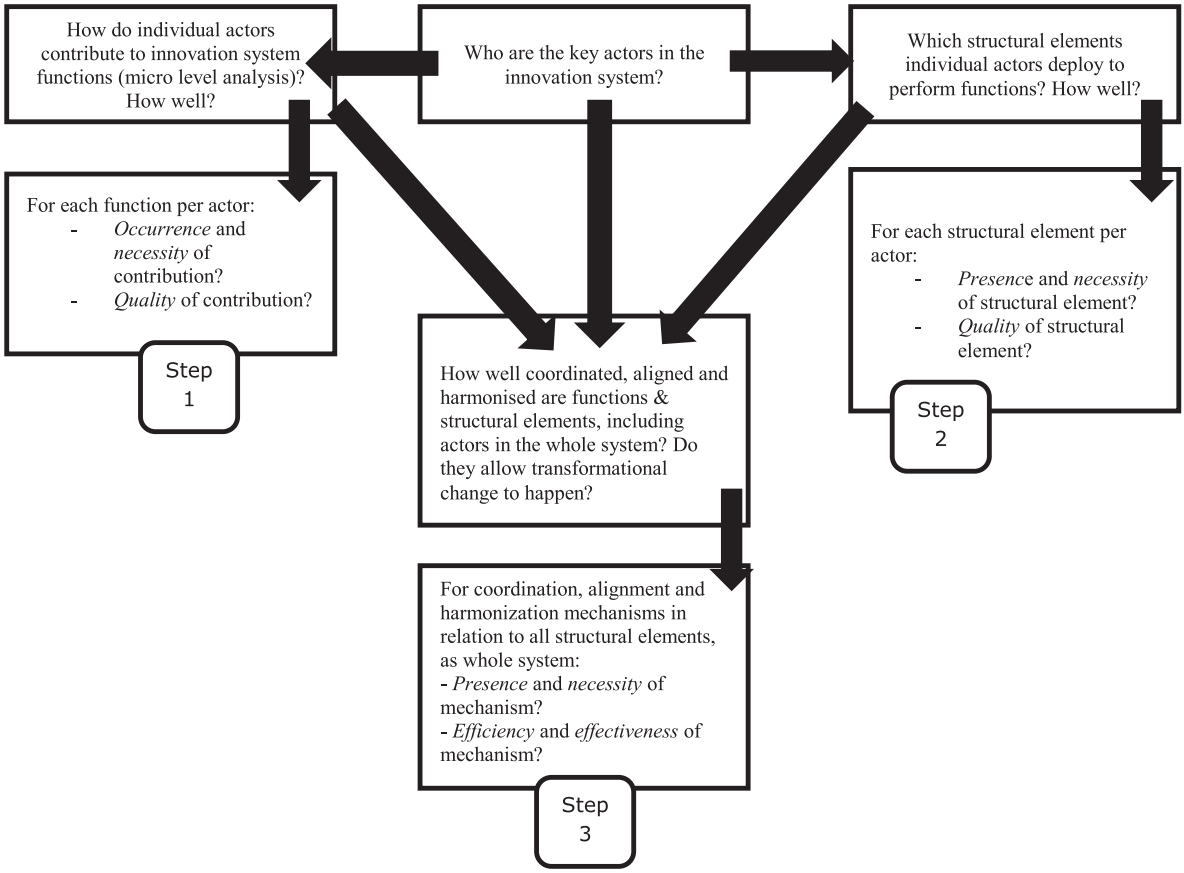

Fig. 2. Integrated framework – analytical level.

Table 1
Matrix 1: to diagnose contribution of innovation actors to innovation system functions (Step 1) (adapted from Wieczorek and Hekkert, 2012). The diagnostic questions (Occurence? Necessity? Weakness?) are asked for all Functions (indicated by ...).

Functions-innovation actors	Function 1: knowledge development	Function 2: Commercial experimentation	Function 3: Knowledge diffusion	Function 4: Funding	Function 5: Mobilise resources	Function 6: Market formation	Function 7: Search guidance	Function 8: Creation of legitimacy
Research domain	Occurrence? Necessity? Weakness?	Occurrence? Necessity? Weakness?	...	...	...	...	...	...
Direct demand/ enterprise domain	Occurrence? Necessity? Weakness?	...	...	...	...	...	...	...
Indirect demand domain	...	...	...	...	...	...	...	...
Intermediary domain	...	...	...	...	...	...	...	...

difficulties in *knowledge diffusion/exchange in networks* especially in their interactions with Scottish farmers. This arises largely from using one-way communication approaches as well as not tailoring their messages to their audiences (the so-called 'language barrier').

Scottish governmental agencies are generally perceived to perform well in terms of identifying-functions (*guidance of the search*, providing *funding*, and *mobilising resources)*, especially when compared to some of their UK counterparts. State funded research bodies such as the UK research councils and Technology Strategy Board (TSB) are seen to perform these functions relatively strongly, but again underperform when interacting with Scottish farmers or agrifood SMEs. The levy boards, funded by a compulsory levy on producers, were identified as having a key role in many areas of the IS and were viewed as having improved their performance in many of their areas of operation. However, some remaining weaknesses were identified especially in *funding* and *knowledge diffusion/transfer*. It is interesting that social interest groups such as NGOs and charities were identified as playing an important role in realizing a number of IS functions (in *creation of legitimacy*, *guidance of the search* and *resource mobilisation*).

Overall, the intermediary domain of the Scottish AIS is seen as underperforming in a number of its key functions such as *knowledge diffusion/exchange in networks*, *creation of legitimacy*, *guidance of the search*, *resources mobilisation*. Although particular innovation brokers such as SAOS and Biosciences KTN and to a lesser extent Scotland Food & Drink (SF&D) were cited by a number of

Table 2
Matrix 2: to diagnose role of innovation actors in relation to system failures (Step 2) (Adapted from Wieczorek and Hekkert, 2012; Weber and Rohracher, 2012). The diagnostic questions (e.g. Presence? Necessity? Quality?) are asked for all domains (indicated by ...).

Categories of failures/ merits	Innovation actors-types of failures/ successes	Research domain	Direct demand/ enterprise domain	Indirect demand domain	Intermediary domain
Structural system failures (F)/merits (S)	Infrastructural F/S (knowledge & physical infrastructure)	Presence? Necessity? Quality?	...	...	...
	Institutional F/S (hard & soft institutions)	Presence? Necessity? Quality?	...	...	...
	Interaction or network F/S	Presence? Necessity? Quality?	...	...	...
	Capabilities F/S	Presence? Necessity? Quality?	...	...	...
Market structure failure (F)/merit (S)		Presence? Necessity? Quality?	...	...	...
Transformational failures (F)/merits (S)	Directionality F/S	Presence? Necessity? Efficiency? Effectiveness?	...	...	...
	Demand articulation F/S	Presence? Necessity? Efficiency? Effectiveness?	...	...	...
	Policy coordination F/S	Presence? Necessity? Efficiency? Effectiveness?	...	...	...
	Reflexivity F/S	Presence? Necessity? Efficiency? Effectiveness?	...	...	...

Table 3
Contribution to realising innovation system functions by Dutch and Scottish AIS actors.

Domain type	Actors type	Typical innovation system functions this actor contributes to	Under-performing contribution to innovation system functions
Research domain	Universities; Research institutes; Private R&D departments (e.g. of companies or NGOs)	Knowledge development; Knowledge diffusion/ transfer; Entrepreneurial activities/commercial experimentation; Market formation	SC: Knowledge diffusion/transfer; Commercial experimentation; Market formation NL: Actors in the research domain tend to have stronger performance than Scottish counterparts, but there is still room for improvement
Direct demand/ enterprise domain	Food supply chain actors (e.g. agricultural input suppliers; farmers, processors; retailers) SMEs; Large enterprises; Cooperatives	Knowledge development; Knowledge diffusion/ exchange; Entrepreneurial activities/ commercial experimentation; Market formation; Guidance of search; Resource mobilisation; Creation of legitimacy	SC: Except for some multinational input suppliers, multiple retailers, other supply actors (especially farmers and indigenous SMEs) underperform in Knowledge development, Commercial experimentation; Market formation. Input suppliers and retailers underperform in Knowledge diffusion/exchange NL: Direct demand actors have stronger performance than Scottish counterparts, but there is room for improvement especially for farmers and SMEs
Indirect demand domain	Final consumers; Governmental agencies; Other policymakers; social interest groups (e.g. charities and NGOs); Related market (e.g. pharmaceutical market)	Knowledge diffusion/exchange; Entrepreneurial activities/Commercial experimentation; Market formation; Guidance of search; Resource mobilisation; Funding; Creation of legitimacy	NL: The Dutch AIS underperforms in Market formation; Creation of legitimacy, but performs better than the Scottish AIS in Innovation brokering
Intermediary domain	Education; Extensive services; Consultants; Actively-supporting levy/trade bodies; Systemic innovation brokers	Knowledge diffusion/exchange; Entrepreneurial activities/Commercial experimentation; Market formation; Guidance of search; Resource mobilisation; Funding; Creation of legitimacy	SC: Generally the intermediary actors underperform in Knowledge diffusion/ exchange; Guidance of search; Resource mobilisation; Funding NL: Innovation intermediary actors have stronger performance than Scottish counterparts

*Explanation of abbreviations: Netherlands (NL); Scotland (SC).

interviewees as supporting these innovation system functions more effectively. Comparing these findings with the Netherlands, agrifood innovation agents were identified as fulfilling similar functions to their Scottish counterparts. However, the internal perception (i.e. from those within the Dutch system) about the functional performance of the AIS is more positive as compared to the perceptions of Scottish respondents on the Scottish AIS. Perhaps the most marked difference is in terms of the perception of both the direct demand for innovation domain (i.e. agrifood supply actors) and the innovation intermediary domain. This relative strength appears to be related to the Dutch AIS having a longer tradition and accumulated experience in cooperation, shared-learning and knowledge co-production, using a multi-stakeholders network approach that also validates and exploits non-scientific knowledge, such as that of the farmer (Klerkx and Leeuwis, 2009a). In many cases, these collaborative networks are self-organised. Thus, the Dutch innovation agents tend to present a more satisfactory performance in *knowledge diffusion/transfer*, *creation of legitimacy*, *guidance of the search*, *resources mobilisation*, and *funding* compared to the Scottish counterparts. In fact the

strong collaboration in Dutch agricultural sector between different partners is often presented by informants and the literature (e.g., Wielinga, 2001) as an example to follow for other Dutch (industrial) sectors.

As mentioned earlier, it is widely recognised by informants and the literature that the abolishment and privatisation of the traditional public 'Education, Extension and Research (EER) triptych' in the UK and NL, led to a proliferation of new knowledge creators and providers (Garforth et al., 2003; Wielinga, 2001; Klerkx and Leeuwis, 2008). Although within the UK there were differences with the privatisation process in Scotland being considerably less severe than in England. In the Netherlands the public extension service has been transformed into a considerably downsized private service, which competes with many emerging smaller (and some large) agro-consultancy firms in what can be called a pluralistic system of advisory service provisioning. In addition, some agrifood firms and NGOs have their own research facilities and universities offer consultancy services. In addition, new private organisational forms as well as new public/private partnerships for research and innovation (e.g. platforms and networks) emerged. This makes the boundaries between functions performed by those traditionally categorised as innovation creators, facilitators and users vague, and the distinction between roles increasingly blurred. Innovation agents have been expanding their functions' range, aiming to add value to their specialist services, and in turn increase their competiveness in the innovation arena. This has occurred through developing new 'in-house' competencies or the entering into of strategic partnerships with organisations with complementary skills.

Whilst the increasingly commercial nature of innovation has produced a range of benefits, some challenges remain. For example, because extension advisory services and consultants have to work on a more commercial and demand-driven basis (basically on what the client is asking for), this has resulted in the disappearance of certain fields of expertise in both countries, due to lack of demand. This has meant that some public goods issues have remained under addressed and the ability of the system to meet some of the emerging challenges has been compromised. Though it should be noted that Scotland has maintained a free-of-charge advisory service delivery relating to public good provision at the farm level at least.

4.2. Systemic structural failures and merits

4.2.1. Knowledge infrastructure

The two systems benefit from a high concentration of universities and research institutes. They also both have a reasonably strong and wide network of education institutions, extension/advisory services and consultants. The knowledge infrastructure appears also reasonably strong and well-spread across the two countries in terms of connection with policy-making agencies and social interest groups (e.g. Scottish Society for the Prevention of Cruelty to Animals – SSPCA, or various groups of nature conservationists and environmentalists in the Netherlands). Linked to the earlier identification of poor functional performance, the knowledge infrastructure of Scottish agrifood businesses is seen as generally rather weak and insufficient, and recognised as having a detrimental effect on the Scottish AIS. In contrast, the AIS Netherlands appears stronger through the activities of research institutes independent advisors, input suppliers, food manufacturing, multiple retailers and farmer peer networks and other self-organised networks.

4.2.2. Physical infrastructure

Both the Scottish and Dutch physical infrastructure appear sufficient, including transportation (e.g. train or road network) or telecommunication systems (e.g. 3G mobile network and broadband) and availability of utilities (e.g. Gas). However, speed and coverage of broadband and 3G mobile network was cited as almost the only significant restricting factors for innovation in Scotland. As informants pointed out, these deficits can potentially inhibit information/knowledge accessibility, interactive learning and ultimately innovation for all categories of innovation actors. However, the most likely affected are Scottish farmers, due to relatively low mobility and farm remoteness.

4.2.3. Funding infrastructure

A common failure for most public-funding instruments appears the very tight EU control of state organisations on what can be funded. This is cited as a barrier in innovation projects, because only the start-up costs, and not the running costs can attract funding even though the on-going capital requirement for covering the running costs is seen as a real constraint for agrifood businesses. However, in the Netherlands, one can increasingly see the implementation of novel innovation support instruments that avoid giving companies the direct financial support that is prohibited by the EU (see Veldkamp et al., 2009, for an example). These are often a mix of public and private funds brought together to invest in start-up companies with a market focus and commercial potential.

Much attention, especially in Scotland, was drawn to the distortions caused by EU farm subsidies that appear to have a strong influence on farmers' behaviour towards innovation. In particular, existing subsidies were regarded as hampering innovation, because they do not create enough incentives for innovation, efficiency and market-orientation. This is evident especially when the sectors are compared to unsupported industries where continuous cycles of innovation are witnessed. In the Netherlands, because of the greater importance of agricultural activities that receive less support (horticulture etc.), the farm subsidies are seen as less influential on the overall innovation process in the agrifood sector. In contrast to farm support, innovation vouchers were considered as a powerful enabling factor for innovation in both AIS. In the Netherlands, specific policies are targeted at innovation and the agrifood sector, with a strong focus on stimulating the match of knowledge demand and supply through the funding of brokering initiatives. At the national level, a high profile 'innovation platform' was formed in 2003, identifying 'TopSectors' for Dutch innovation, including the flower and food sectors.

Production-oriented research in both countries is often funded by farmer or agribusinesses' (e.g. dairy cooperatives, abattoirs) levies, which are a sector specific tax. Though it appears that more of the levy is directed at research determined by farmers needs in the Netherlands (Klerkx and Leeuwis, 2009b) when compared to Scotland. A particular issue for Scotland is that these levies have recently been reclassified as public/government money (due to their mandatory nature) which automatically means that they cannot be counted towards industry's required monetary contribution for research funding that requires a combination of industry and public funding (for example that supported through the Technology Strategy Board). In the Netherlands, however, the levy system has been recently abolished, and whilst in different sectors alternatives are searched to fund sector relevant production-oriented research on a voluntary basis, it is uncertain what will be the outcomes of these efforts.

4.2.4. Hard institutions

As mentioned earlier, both the Netherlands and Scotland operate within the legal and institutional framework of the EU and therefore much of the overarching legislation is similar (for example the Common Agricultural Policy, Nitrates Directive, Water Framework Directive etc.). In both countries, informants reported

the following regulations as having the most impact on innovation: environmental regulations that have restricted the options for intensive animal production (particularly in the Netherlands); spatial planning laws; employment legislation and; health and safety regulations. In the Netherlands, as a highly-populated country, spatial planning laws are a particular issue with municipalities enforcing zoning rules and granting permission only for specific activities. At the same time, agrifood industries in both countries have emphasised the need for greater government support in reducing the burden of EU/government imposed regulations, cutting the 'red tape', and making flexible and streamlined regulations.

On a more positive note, R&D tax credits and tax breaks, and Intellectual Property rights (IP) such as patents and trademarks were considered as powerful enabling factors for innovation in the IS of both countries. Though it is observed that application procedures for innovation support instruments (e.g. funding) were considered too complex, cumbersome and laborious (particularly for SMEs). Despite its potential for substantial positive impact, the use of innovation-oriented procurement mechanisms (that is innovativeness becomes a criterion for supplier selection) to directly stimulate the advancement of novel solutions is rather weak in both Scotland and the Netherlands.

One example of particular issues that emerged through the research process was the EU ban on GMO technologies. This was regarded by many interviewees as posing a significant barrier to innovation, and as such potentially threatening the competitive position of the EU, Scottish and Dutch agrifood sectors.

4.2.5. Soft institutions

Although with some exceptions, it seems that the laws, regulations and standards (hard institutions) are relatively similar between the two countries, greater differences begin to emerge when considering soft institutions. The view is that at present, the demand for innovation from Scottish farmers is not that strong, where most farmers appear to be rather passive receivers of advice, mostly for everyday management issues. This is evident from farmers' willingness to pay consultants for advice for administrative tasks (such as claiming CAP support) rather than seeking advice on innovative production and management practices. In the Netherlands, advisory services also concentrate on accountancy, legal advice regarding spatial zoning and environmental regulations rather than production.

In addition in Scotland, other AIS stakeholders talk of an attitude amongst researchers and consultants that hinders the development of relationships with their customers, classified by interviewees as 'intellectual arrogance'. This refers to the subjective belief of having superior knowledge to that of their customers, and not accommodating the knowledge, perceptions and values of farmers and other industry actors. In contrast such an attitude amongst researchers and consultants is far less apparent in the Netherlands, and this was attributed to the long tradition of engagement in multi-stakeholders collaborative networks for learning and knowledge exchange. There is strong focus on learning in peer-to-peer networks, with study clubs being unabatedly popular. Apparently, collaboration and the idea of communities of practice are historically well developed in the Dutch AIS.

It was argued by informants that, in part at least, these weaknesses emerged in Scotland because of the prevailing culture across Scottish research providers, that conducting research, publishing in academic journals or reporting to public funders takes a much higher priority than communicating research findings to knowledge exploiting organisations. Thus, organisational culture and institutional barriers are blocking innovative initiatives. Although, there is a relatively greater pressure on Dutch researchers towards translating and communicating research findings, interviews revealed that lessons drawn from successful cases still not been disseminated as widely as could be the case.

On a more positive note, examples were provided from both countries of participatory and knowledge co-producing networks, some of which have a profound educational impact, and are promising initiative in fostering innovation. Overall, the Dutch, and recently the Scottish AIS have built a repository of positive local experiences from experimentation in learning and collaborative arrangements fostering innovation. These repositories potentially form a good basis to develop the knowledge exchange/networking approach even further, by drawing lessons and attempting to transfer these lessons to other areas or agrifood sub-sectors. In both countries, the farming press is a key mechanism for communicating innovation developments, as most farmers still like to receive information in written form next to exchange with peers and consultants.

4.2.6. Weak networks

One major weakness evidently relates to that in many respects Scottish universities have stronger links with spin-outs and externally-owned (international or other UK-owned) firms than with indigenous SMEs. The former tend to have higher absorptive capacity and ability to capitalise on the knowledge generated at Scottish universities (e.g. maximise royalty revenues from licensing). Similar findings on SME's absorptive capacity were provided in the Dutch case. Moreover, Scotland's universities appear not to regard indigenous SMEs as being good vehicles for licensing activity, compared to spin-outs or large-scale companies, often international in scope. In contrast, the Dutch AIS benefits from short lines between policy makers, research institutes, agri-businesses and farmer unions, in which strategic cooperation is key. In particular, the close connection of WUR-government-businesses has become a role model for other Dutch sectors to follow and is featured prominently in the new TopSectors (Platform) innovation policy. A much more fragmented knowledge infrastructure is perceived to be apparent across the whole fabric of the Scottish AIS, evident in too rigid linkages between Research-Consultancy-Education. According to informants and the literature (Klerkx and Leeuwis, 2008), the Dutch AIS benefits from a wide array of innovation brokers and intermediaries which are established to function as 'catalysts of innovation' and 'market facilitators', by connecting innovation demand and supply in the markets of R&D and extension services. In Scotland, the array of systemic innovation brokers is smaller and has more recently developed.

4.2.7. Strong networks

Efforts in Scotland to link research to industry (i.e. overcoming directionality failure) by the SG (Scottish Government), TSB (Technology Strategy Board) and UK research Councils are only partially successful. First, these efforts are argued to have led to a strong network failure, where interactions are too dense between public funders with researchers, compared to their ties with other stakeholders preventing novel insights or inspirations to emerge. Often this is reflected in a commonality in the language used by policy-makers and researchers that is in contrast to the language of agrifood businesses, levy or trade boards. Second, it was argued that this observed consensus between policy-makers and researchers was the result of policymakers' power over researchers as the main source of research funding. Although a high level of dependency of R&D institutes on the government ministries representing agriculture is observed in both countries. Some interviewees suggested that both Scottish and Dutch policymakers tend be more sensitive to the voice and influence of social interest groups such as NGOs rather than to that of agrifood businesses, levy or trade boards, and consumers. In Scotland it was argued that the prevailing model in supporting innovation, traditionally was and remains

supply (research)–driven, providing less opportunities to generate solutions that fit the needs of agrifood businesses, levy or trade boards. This generates a mismatch between the type of knowledge being generated and that which is demanded. In the Netherlands, systems to support innovation amongst agrifood entrepreneurs have moved from supply-driven and prescriptive to having a clearer demand-driven character therefore requiring more initiative from entrepreneurs. Moreover, the Dutch policy stresses the importance of inclusivity i.e. inter-disciplinary research projects involving a wide array of scientists, businesses, government agencies and NGOs in the process of creating knowledge and innovation.

4.2.8. Capabilities

According to informants, in both countries, there are problems with an ageing population within the sector, and attracting a sufficient and well-educated labour force, given the sector's negative image among young people. There has been until recently a decreasing inflow of new students for studies focussing on primary production, both at the level of higher education, but especially the mid-level and vocational jobs. In recent years, labour needs in both countries have been met by labourers from Eastern European countries who perform manual tasks on farms and in glasshouses. There is a shared concern about the availability and the quality of labour force that has led the industry, together with unions and agricultural schools in developing campaigns to attract more students.

Current systems to support innovation in Scotland and the Netherlands require more initiative from agricultural entrepreneurs, so as to be less supply-driven and prescriptive. This calls for competences with regard to knowledge and information acquisition and learning for innovation, i.e. sufficient absorptive capacity. Findings in both countries suggest that such competences are often lacking in agrifood SMEs and farms. This affects their ability to define strategic, organisational and technological deficiencies in their efforts to express clear demands to researchers and advisors. Apart from competencies, farmers often lack resources such as time and funds to invest in new knowledge and technology.

Provided that there are skilful facilitators playing the role of translators the language barrier between researchers and farmers/agrifood businesses can be overcome. However, findings on the situation in Scotland suggest that the direct relationship between researchers – farmers/agribusinesses is often problematic. This is due to the sometimes weak communication skills of researchers – in translating research findings into a simple, practical language, understandable by this particular audience. This may imply the need for research institutes to recognise that effective communication skills with industry actors may differ from the R&D skills. Furthermore, instead of requiring from any researcher to become an effective communicator, our findings strongly supports the strategy of identifying the people that already have proven adequate skills, and use them exclusively to facilitate sharing knowledge between researchers and users. In the Netherlands, such needs appear already recognised and served. In fact, amongst consultants and advisory services, there are many managers of innovation processes available. Innovation brokering (i.e. systemic facilitation contributing to setting up and maintaining effective innovation networks) is also starting to get more attention in the education curriculum, at least at the university level.

4.3. Market structure failures and merits

In both countries there is the strongly held view that the privatisation of research and extension services led to a more competitive rather than collaborative approach being adopted to knowledge, with the resultant effect that there is less willingness to share information either amongst different research providers or between research and extension/advisory services. Information that was freely exchanged in the state schemes of linking agricultural researchers with extension services and farmers, has become a (potentially) purchased commodity with actors feeling that it is in their interest to protects its commercial value. As a result, information asymmetries are apparent in the Dutch and Scottish AIS. In the Dutch AIS, for this purpose, specialised innovation brokers have emerged that match demand and supply in the agricultural 'knowledge market' and help setting up innovation networks (Klerkx and Leeuwis, 2008), and there are indications that in some places in the UK the advisory system has self-organized to restore coherence (Klerkx and Proctor, 2013).

Overall, commercialisation and privatisation of knowledge have been indicated to slowed down knowledge and innovation diffusion. On the demand side, Scottish and Dutch farmers appear to have less incentive to seek knowledge under the privatised system for a number of reasons. First, the charged fee rates are significant. Second, there is some mistrust as to the neutrality of knowledge/information providers as having own-commercial interests. Third, 'information smog' has been created as the proliferation of knowledge providers has meant mixed messages emerge as to the value of new technologies or processes. Consequently, *the* industry faces difficulties in terms of scanning the market, assessing differences in providers' quality, ex ante evaluating service value, and in many cases even identifying the provider(s) possessing the needed piece of information/knowledge they are looking for. The observed information asymmetry complicates the search for and selection of suitable cooperation partners, and raises transaction costs. In addition challenges emerge from the economic changes that the food sector face, where pressing short-term economic issues distract the supply-chain actors from longer-term sustainability goals.

Both the Scottish and Dutch agrifood sectors have undergone significant structural change becoming increasingly consolidated through a dynamic process of mergers, acquisitions, vertical integration, joint ventures and market exit. Farmers in both counties are confronted with substantial concentration on either side of the farming sector: upstream i.e. agricultural input providers and downstream side i.e. food manufacturing and especially in food retailing sector (IFAP, 2002). A few large firms dominate both in the input and distribution sides of the agri-food chain. There is genuine concern in the farming community and their levy boards that as a result, farmers have significantly less choice from whom to buy their inputs and to whom to sell their product, or about what and how to produce. There are mixed views on the impact of these changes in market power on the innovation process. For example, some interviewees argue that retailer concentration and excessive bargaining power act as an innovation barrier, particularly in Scotland. Others credit multiple retailers with being the real driving force for innovation within agrifood supply chains, and also offering food manufacturers and their supplying farmers an increased access to consumers. The findings suggests that food processors/manufactures tend to (sometimes be forced to) respond to retailers' demands which can drive innovation. It is clear that many firms, especially SMEs, in the agrifood chain in both countries operate on very tight profit margins. These, tighter margins and lower access to finance after the economic downturn, are seen as posing significant barriers to both business growth and the innovation process. This is because they affect the ability and willingness (confidence) of farmers and agrifood companies to invest in knowledge and innovation development. The findings suggest that Scottish farmers, to an extent, remain dis-organised and scattered, resulting in weak market power, and vulnerability to attempts by the large firms to exert control. In contrast farmers in the Netherlands appear more organised and willing to work collaboratively to secure greater power in the supply chain.

4.4. Systemic transformational failures and merits

4.4.1. Demand articulation failures and merits

Seeing researchers' behaviour from a slightly different perspective, some informants can see a demand articulation failure i.e. a deficit in anticipating and learning about user needs (Weber and Rohracher, 2012). First, the Scottish case provided evidence that researchers often do not seem to appreciate the innovation needs and expectations in terms of knowledge exchange of particular categories of funders, such as levy/trade bodies, farmers' organisation or the industry. This demand articulation is often related not only to setting the agenda for research and matching demands for research with supply, but also associated to orienting other services to support innovation (e.g. to construct an integrated farm system for instance to address a range of animal health and welfare issues). This seems to be in contrast to the situation in the Netherlands, where there are several initiatives to do joint research and innovation agenda setting (Klerkx and Nettle, 2013). Overall, a mismatch between the ability or willingness of research providers to help and the requirements of knowledge exploiting actors e.g. levy/trade bodies or the industry, especially indigenous SMEs, is apparent in Scotland. Furthermore, some interviewees pointed to the lack of recognition that customer relationship management is a very vital, and different set of capabilities from R&D skills. As a result, most Scottish universities and research institutes have not arranged a single contact point for customers, but rely on individual researchers' skills and willingness to build (personal) relationships with commercial customers (e.g. retailers or input suppliers, but also advisors and farmers). This fragmented approach on customer relationships is recognised as a barrier to innovation. In the Netherlands, research institutes have relationship managers, which make connections with large clients, but also participate in agenda setting for farm level research issues, which is generally done through broad stakeholder consultation.

4.4.2. Directionality failures and merits

In the Netherlands, there is no one actor, or a coalition of actors, able to unite the whole agrifood sector behind a single vision (Hermans et al., 2012). The Dutch government takes a 'hands-off' approach, namely that the sector should be able to develop the way which entrepreneurs want to take, depending on where they see their business opportunities. Although there is not one shared vision, a positive note is that agrifood innovation policies do support diversity of different possible futures. In contrast, the Scottish government has taken a more 'hands-on' approach, after seeing that market forces had not eliminated deficits in the functioning of the Scottish AIS, and there was a lack of leadership from within the system. So, the Scottish government attempts to define a direction by setting collective priorities in research and innovation that need to develop solutions for identified major societal-natural challenges e.g. climate change or sustainable agriculture. It also demands the integration and collaboration of the land-based research institutes. However, some Scottish interviewees argued that creating a shared vision and setting strategic targets is just the beginning, but the practical strategy of 'how' to achieve these targets has yet to be seen. Behind the issue of the difficulty of articulating a common vision, are issues of interests and accountability mechanisms. In particular, scientists are primarily evaluated on the peer-reviewed publications, farmers and agribusinesses on profitability, while governments are evaluated on delivering public goods and not 'wasting' taxpayers money on uncertain and possibly controversial innovations.

As a response to the need of accommodating better the needs of the Scottish agrifood businesses, the Scottish government has strongly supported the establishment of non-for-profit organisations as systemic innovation brokers, such as Scotland Food & Drink (SF&D), Interface, Scottish Agricultural Organisation Society (SAOS), Food & Health Innovation Service (FHIS) Scottish Enterprise (SE) and Highland & Island Enterprise (HIE). The Scottish government assigned SF&D a leadership role and tasked with guiding Scotland's food and drink companies of all sizes towards increased profitability and competiveness in domestic and global markets. Innovation is a central element of SF&D's strategy.

In Scotland, the TSB has formulated an innovation agenda including energy (with a particular focus on renewables), food and drink sector (that comprises agriculture and fisheries) and tourism. In the Netherlands, innovation agendas have been formulated for the separate sectors e.g. the dairy sector, horticultural sector, poultry sector, etc. in cooperation with commodity boards and farmers' organisations. However, the national innovation policy aims at sectors e.g. TopSectors/Innovation Platform, with little room for inter-sectoral innovation. At the same time, there is sometimes a tension between collective and private interests with regard to funding and goals of innovation support instruments (Klerkx and Leeuwis, 2009b; Klerkx and Jansen, 2010).

4.4.3. Policy coordination failures and merits

Both the Dutch and Scottish governments have made a steady progress towards overcoming another IS failure, namely policy coordination failure that goes beyond directionality failure. In particularly, both governments have attempted to create coherent policy impulses from different policy avenues to ensure transformational changes in most layers of their national AIS (see e.g. Klerkx and Leeuwis, 2009b; Veldkamp et al., 2009 for the Dutch case, and as indicated by key informants for the Scottish case). Findings suggests that although progress has been made towards this direction, there is still considerable room for improvement. Incidents were reported by informants that interpretation and application of specific EU directives or government strategies sometimes differs amongst municipalities or governmental agencies.

4.4.4. Reflexivity failures and merits

Due to the uncertainty and inherent unpredictability surrounding innovation and sustainability challenges, interviewees in both countries acknowledged that although more fundamental scientific research is absolutely necessary, supplying even more of that alone is not going to solve these issues. Instead, interviewees called for more involvement of societal 'stakeholders' i.e. those actors that are either affected by, or possess the ability to influence its development. Interviewees pointed to the need of the Dutch and Scottish AIS to involve multi-actors in processes of reflection and self-governance by providing sufficient platforms for interaction and spaces for experimentation, monitoring and learning. Both the Scottish and Dutch governments have been moving in this direction, e.g. through the funding of specific innovation programmes and think tanks acting as such platforms in the case of the Netherlands (Klerkx and Leeuwis, 2008a; Veldkamp et al., 2009). However, interviewees sometimes questioned their ability to stop or alter policies that turned out to be less promising than initially expected. Another particular issue identified regarding the IS reflexivity relates to 'learning from past experiences' regarding innovation policies. This function is hardly present in the Netherlands and Scotland. After a particular subsidy or innovation program ends, there is (no or) insufficient interest in evaluating its actual contribution properly. Such evaluation exercises could support transforming tacit to codified knowledge and help disseminate lessons learned to future initiatives/policies.

5. Discussion and policy implications

In this section we reflect upon findings with regards to: (i) the performance of the different innovation systems, (ii) policy

implications for strengthening the innovation capacity in both countries, and (iii) applicability of the integrated framework, teasing out also the lessons from cross country comparison, that may be transferable to AIS in other countries under different constraints and requirements.

5.1. Comparison of the performance of the Dutch and Scottish agrifood systems

To enable comparison, findings presented in detail in Section 4 are summarised by a scoring list (see Table 4). In some cases, more scores than one are given to represent alternative realities that exist in each IS. For instance, for hard institutions, the indirect demand domain in the Dutch agrifood system employs various policies, of which some have a positive quality/impact (e.g. R&D tax credits and tax breaks), while others' effect is negative (e.g. spatial planning laws, procurement mechanisms that do not prioritise/support innovation). That respondents considered all categories of systemic successes/merits as necessary confirms the appropriateness of including them into the framework and analysis.

Overall, for both countries the factors enabling or facilitating innovation include a strong knowledge infrastructure of the research and indirect demand domains, sufficient physical infrastructure (except for broadband and 3G mobile network in Scotland), a steady progress to improve policy coordination and directionality. On the contrary, innovation-hindering factors that are common in both countries concern problematic hard institutions such as 'red tape' of EU/governmental regulations and complex applications procedures for innovation, insufficient capabilities of the direct demand sector, weak reflexivity and market structure. Except for directionality advantage due to the Scottish government's 'hands on' approach, the Dutch AIS seems better positioned to foster innovation. In particular, this results from having stronger soft institutions, interactions (e.g. Top Sectors Platforms and a wider array of innovation brokers and intermediaries), demand articulation and communication skills of the research and intermediary domains, as well as novel public-funding instruments.

In the Scottish AIS there is a paradox where knowledge generation through universities and research institutes is well developed, with some consistently ranking among the most productive in Europe. However this knowledge fails to generate new innovation and agrifood business opportunities within Scotland. In the Netherlands the AIS is considered to be performing quite well, and serves as an example for innovation policies. This may seem somewhat anomalous, given that our results seem to suggest that many systemic failures found in the Dutch and Scottish AIS were almost identical such as the impact of privatisation and commercialisation of extension services on the knowledge infrastructure. This may be an indication similar trajectories and associated needs in the evolution of both agricultural innovation systems over the years, in terms of how value chains and policies have developed. This was consistent with the logic of common starting point but potential developmental pathways that support the comparison between the agrifood systems in the Netherlands and Scotland.

However, whilst there were many similarities in the formal (hard) institutions such as laws, regulations, and standards between the two countries, the intensity of their negative or positive impact on innovation differs. It appears that the impact of innovation-targeting mechanisms seems to be directly affected by traditions and culture in each country (soft institutions) e.g. the Dutch agricultural sector's inclination for collaboration, working on the basis of consensus, learning networks, and knowledge co-production (Wielinga, 2001). This influence of culture is consistent with earlier work which highlights the influence of such soft institutions (Hall et al., 2001; Millstone et al., 2010). This tradition in the Netherlands may explain the more 'hands-off' approach from the government, compared to the Scotland, where the need to undertake a vision building strategy mentioned earlier emerged from the Scottish government.

5.2. Policy implications

This section discusses the policy implications with regards to the:

- impact of country's innovation culture
- challenges of collective learning and managing the accumulated experiences
- importance of involvement of more multi-stakeholders
- impact of blurred boundaries in the roles of innovation actors
- importance of assessment of fields of expertise of insufficient commercial interest.

5.2.1. Impact of a country's innovation culture

Following on from the analysis above, a reasonable policy implication is that the policymakers' awareness and attention on the long tradition and culture of a country are crucial to predict the tolerance of its people to innovation policies of different levels of state intervention (following earlier work by Tödtling and Trippl, 2005 and Klerkx and Nettle, 2013). From the comparison of the two countries is becomes apparent that these have different levels of maturity in terms of their propensity and capacity to innovate. In other words, it was interesting to see what kind of challenges faces a society (or agrifood system) that appears to have already comprehended the importance of multi-stakeholders collective learning, and have progressed with experimentation in learning networks, such as the Dutch agrifood system. For instance, when a sufficient degree of inclusiveness, seeking consensus and co-learning in culture is apparent, this works well and for a longer period with a 'hands-off' state policy that avoids intervention in market processes to eliminate inefficiencies related to innovation. On the contrary, countries lucking such a culture are more likely to justify policy intervention sooner to address deficits in the IS functioning. However, the difficulty and the public goods character of transformational change puts a threshold beyond which a 'hands-on' approach from the government is required to speed up the transition towards more advanced innovative and sustainable production and consumption systems. Policymakers need to be aware of this observation.

5.2.2. Challenges of collective learning and managing accumulated experiences

The emerging central question is whether it is easy for actors to manage the accumulated experiences in fostering innovation processes, transform them from tacit to codified knowledge and disseminate lessons learned?. Overall, the Dutch, and more recently the Scottish AIS have built a repository of positive local experiences from experimentation in learning and collaborative arrangements fostering innovation. However, the research findings suggest that there are difficulties in managing such cumulated experiences in the Netherlands and Scotland for policy formulation purposes. After a particular subsidy or innovation policy initiative ends, there is (no or) insufficient interest in evaluating its actual contribution properly, or evaluations are not coherently translated into policy actions. Consequently, the policy implication here concerns that such evaluation exercises could support transforming tacit to codified knowledge and help disseminate lessons learned to future initiatives/policies, hence putting more attention to what Borrás (2011) refers to as 'policy learning' .

Table 4
Matrix 2 – innovation actors contribution to systemic failures/merits – application on the Scottish and Dutch agrifood innovation systems.

Categories of failures/merits	Innovation Actors-types of failures/ successes	Research domain	Direct demand/ enterprise domain	Indirect demand domain	Intermediary domain
Structural system failures (F)/merits (S)	Infrastructural F/S (knowledge & physical infrastructure)	**NL**: P+++; Q+++ **SC**: P+++; Q+++	**NL**: P++; Q++ **SC**: P-; Q–	**NL**: P++; Q++ **SC**: P++; Q++	**NL**: P++; Q++ **SC**: P+; Q+
	Institutional F/S (hard institutions)	**NL**: P++; Q++ **SC**: P + &-; Q++	**NL**: P + &-; Q+ **SC**: P + &-; Q + &-	**NL**: P++; Q–&++ **SC**: P + &-; Q–&++	**NL**: P++; Q++ **SC**: P+; Q + &-
	Institutional F/S (soft institutions)	**NL**: P++; Q++ **SC**: P+; Q—	**NL**: P++; Q++ **SC**: P+; Q—	**NL**: P++; Q++Y **SC**: P+; Q—	**NL**: P+++; Q+++ **SC**: P++; Q++
	Interaction or network F/S	**NL**: P+++; Q+++ **SC**: P++&—; Q + &–	**NL**: P+++; Q++&- **SC**: P—; Q—	**NL**: P+++; Q+++ **SC**: P–; Q—	**NL**: P+++; Q+++ **SC**: P–; Q—
	Capabilities F/S	**NL**: P++; Q++ **SC**: P—&+; Q—&+	**NL**: P–&+; Q–&+ **SC**: P–; Q	**NL**: P++; Q++ **SC**: P++; Q++	**NL**: P+++; Q+++ **SC**: P–&+; Q–&+
Market structure failure (F)/ merit(S)		**NL**: P–; Q– **SC**: P—; Q—	**NL**: P–&+; Q– **SC**: P—&+; Q—	**NL**: P+; Q+ **SC**: P+; Q+	**NL**: P–; Q– **SC**: P—; Q—
Transformational failures (F)/ merits (S)	Directionality F/S	**NL**: P+; Efi+; Efe+ **SC**: P+; N:Y; Efi+; Efe+	**NL**: P+; Efi+; Efe+ **SC**: P + &-; Efi+; Efe+	**NL**: P–&+; Efi–&+; Efe— **SC**: P+++; Efi++&-; Efe++&-	**NL**: P+; Efi+; Efe+ **SC**: P + &-; Efi+; Efe+
	Demand articulation F/S	**NL**: P+++; Efi+++; Efe++ **SC**: P—; Efi—; Efe—	**NL**: P+; Efi+; Efe+ **SC**: P–; Efi—; Efe–	**NL**: P+; Efi+; Efe+ **SC**: P–; Efi—; Efe–	**NL**: P+++; Efi+++; Efe++ **SC**: P++&-; Efi++&-; Efe++
	Policy coordination F/S	**NL**: P++; Efi++; Efe++ **SC**: P+; Efi+; Efe+	**NL**: P-; Efi-; Efe- **SC**: P-; Efi-; Efe-	**NL**: P++; Efi+; Efe + &– **SC**: P++; Efi+; Efe+&–	**NL**: P++; Efi++; Efe++ **SC**: P+; Efi+; Efe+
	Reflexivity F/S	**NL**: P-; Efi-; Efe- **SC**: P—; Efi—; Efe—	**NL**: P-; Efi-; Efe- **SC**: P-; Efi-; Efe-	**NL**: P+; Efi+; Efe+&– **SC**: P+; Efi+; Efe+&–	**NL**: P+; Efi–; Efe— **SC**: P+; Efi–; Efe—

*Explanation of abbreviations: Netherlands (NL); Scotland (SC); Presence (P), Quality (Q), Efficiency (Efi), Effectiveness (Efe); positive respondents' answers (+); Negative respondents' answers (−). The three +++ or — indicate a very strong positive or negative response from the respondents respectively, compared to the sole + or − which indicate "relatively positive" or "relatively negative" respectively.
*All respondents considered all categories of systemic successes/failures as necessary, therefore for simplicity reasons we have removed necessity from the table.

5.2.3. Importance of involvement of multiple stakeholders

An additional policy implication and lesson for practitioners underlined by informants in both countries is that due to the uncertainty and inherent unpredictability surrounding innovation and sustainability challenges, although fundamental scientific research is necessary, supplying even more of that alone is not going to solve these issues. Instead, informants called for more involvement of societal 'stakeholders' i.e. those actors that are either affected by, or possess the ability to influence its development. Informants pointed to the need of especially the Scottish AIS to involve multi-actors in processes of reflection and self-governance by providing sufficient platforms for interaction and spaces for experimentation, monitoring and learning, which then act as so-called 'systemic instruments' improving overall innovation system interaction (following Wieczorek and Hekkert, 2012). One such a manifestation of a systemic instrument can be dedicated organisations in the intermediary domain who aim to optimise interactions in innovation systems (Klerkx and Leeuwis, 2008) or this role can also be played by actors in the other domains ('hybrid actors)' that create interactions as a means to promote their own interests (Elzen et al., 2012). However, Scottish interviewees sometimes questioned the ability of such platforms for interaction to stop or alter policies that turned out to be less promising than initially expected. Policymakers need to be also aware of this ability.

5.2.4. Impact of blurred boundaries on the roles of innovation actors

The analysis based on actors and functions clearly illustrates how the distinction between roles is becoming increasingly blurred (following an earlier expectation of Den Hertog 2000). For example, some NGOs have their own-research facilities and universities offer consultancy services. In addition, new private organisational forms as well as new public/private partnerships for research and innovation (e.g. platforms and networks) have emerged. This makes the boundaries between functions performed by those traditionally categorised as innovation creators, facilitators and users vague. Innovation agents now have been expanding their range of functions, aiming to add value to their specialist services, and in turn this has increased the level of competition within the innovation arena. Innovation-related functions are mainly extended in scope by either acquiring new 'in-house' competencies or entering into strategic partnerships with organisations with complementary skills. This implies that policymakers need to be aware of increasingly blurred boundaries in the roles of innovation actors (following Den Hertog, 2000). Consequently, policymakers should not draw too rigid lines when design policy initiatives in terms of who is eligible for support and the types of activities that may fit in a policy scheme. Instead, policymakers need to leave room for actors and their roles to develop in unanticipated ways (e.g. novel combination of roles), which requires adaptive policy making and flexible combinations of policy instruments (following Borrás and Edquist, 2013; Klerkx and Nettle, 2013).

5.2.5. Importance of assessment of fields of expertise of insufficient commercial interest

Whilst the increasingly commercial nature of innovation has produced a range of benefits some challenges remain. For example, because extension advisory services and consultants have to work on more of a commercial and demand-driven basis, this has resulted in the disappearance of certain fields of expertise in both countries, due to lack of demand (following earlier risks identified by Kidd et al., 2000, and recent observations by Labarthe and

Laurent, 2013). This has meant that some public good issues have remained under-addressed and the ability of the system to meet some of the emerging challenges has been compromised, though it should be noted that Scotland has maintained a free-of-charge advisory system relating to public good provision at the farm level. The major implication here is that for policymakers it is crucial to regularly assess which fields of expertise, especially those related to public issues, receive limited attention due to insufficient commercial interest, therefore based on the societal needs if they are considered still necessary to create conditions that foster their growth (e.g. stimulate demand articulation) and formulate specific 'public good projects' (see Klerkx and Jansen, 2010).

5.3. Reflections on the use of the integrated framework

The findings confirm the appropriateness of considering actors, functions, systemic structural, market and transformational failures (or merits) together as complementary analytical tools to evaluate the performance of AIS. The integrated framework has helped to produce a richer and more systematic analysis, compared to using some of the aforementioned analytical tools in isolation. Earlier empirical research like Ortiz et al. (2013) mainly focused on actors, their roles and interactions, or like Amankwah et al. (2012) and Gildemacher et al. (2009) mainly concentrated on the structural failures, but did not consider innovation system functions or transformational failures. Instead, the proposed integrated framework adds a more holistic perspective, built on complementarities of existing analytical tools (Wieczorek and Hekkert (2012) and of Weber and Rochracher (2012). However, limitations and lines for further research need to be taken under consideration. Limitations of this study include: (1) the focus on only two countries, both belonging to the EU. We anticipate that the application of the integrated framework on the national AIS of more countries, including those outside the EU will enable better assessment of its validity, and strengthen its value as an analytical tool; (2) the study has an ex-post character, which means circumstances may have changed in the meantime, and respondents' information may be not be completely up-to-date; (3) Its requirements in terms of data, means that substantial investment is needed to gather data from informants and broad literature review.

6. Conclusion

Building on recent insights from innovation studies, this paper tries to reconcile four approaches developed to inform innovation policies, namely the (i) structures and (ii) functions of innovation systems, (iii) systemic structural failures and (iv) transformational failures. By re-framing some key insights from structural and functional studies in a failures language, an extended framework has been developed for addressing the more strategic and long-term needs of goal-oriented transformative change, beyond the narrow scope of innovation performance. The proposed integrated framework overcomes the inherent limitations of only looking at market and systemic structural failures approaches that "are confined to addressing structural deficits in innovation systems" (Weber and Rohracher, 2012, p. 1042). Instead, it captures the evolutionary nature of transformative change, and thus introduces in policy design and implementation the idea of management of socio-technical transitions, and associated strategic choices "that are geared towards stimulating and enabling transformative change in innovation" (Weber and Rohracher, 2012, p. 1046). The proposed integrated framework goes beyond analysis of how individual actors contribute to fulfilling innovation system functions to also examine functioning of the whole system at its most aggregate form (broad/macro level). By 'signalling' problems in functioning at both the narrow and broad levels, the paper facilitates the design of policies that fulfil multiple aims in an integrated manner, supporting the design of 'systemic innovation policy mixes'. Thus the proposed integrated framework represents a checklist of areas of improvement and elements worth preserving within a defined AIS.

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