



Establishment and embedding of innovation brokers at different innovation system levels: Insights from the Dutch agricultural sector

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ABSTRACT

In the systems perspective on innovation, co-operation between several different types of actors is seen as key to successful innovation. Due to the existence of several gaps that hinder such effective co-operation, the scientific and policy literature persistently points at the need for intermediary organizations to fulfill bridging and brokerage roles. This paper aims to provide an overview of the insights from the literature on such 'innovation brokers', and to contribute to the literature by distilling lines of enquiry and providing insights on one of the lines identified. Taking as an empirical basis experiences with different types of innovation brokers that have emerged in the Dutch agricultural sector, it identifies a number of tensions with regard to the establishment and embedding of such organizations. The paper indicates that, despite being perceived to have a catalyzing effect on innovation, innovation brokers have difficulty in becoming embedded as their clients and/or financiers find it difficult to grasp the nature and value of their activities.

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1. Introduction

1.1. Systemic intermediaries in innovation networks and innovation systems

Systems thinking in innovation studies has become widespread, inspired by approaches such as national, sectoral, and technical systems of innovation [1–3]. As Smits [4] states, innovation calls for an effective combination of hardware, software, and orgware. Hardware relates to the material equipment required, and software concerns the knowledge in terms of manuals, software, digital content, tacit knowledge involved in the innovation. Orgware refers to the organizational and institutional conditions that influence the development of an invention into an innovation and the actual functioning of an innovation. Hence, production and exchange of (technical) knowledge are not the only prerequisites for innovation; several additional factors play a key role, such as policy, legislation, infrastructure, funding, and market developments [5]. With the growing importance of user orientation and user involvement in innovation processes [6] and the trend of 'open innovation' [7], an important question is how to adequately perform networking for innovation [8,9]. Such networking is about establishing connections between the demand side (intermediate and end-users of innovations, such as firms) and the supply side (Knowledge Intensive Business Services [KIBS] and R&D providers) of the knowledge infrastructure,¹ as well as establishing other relevant connections (e.g. firms with other firms, firms with hardware suppliers, researchers from different disciplinary backgrounds).

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¹ Smith [10] refers to a knowledge infrastructure as a complex of public and private organizations and institutions whose role is the production, maintenance, distribution, management and protection of knowledge. These institutions possess technical and economic characteristics that are not dissimilar to those of physical infrastructure. Whereas this definition appears to focus principally on the supply side of the knowledge infrastructure, current innovation systems thinking emphasizes the role of the user in the co-creation of knowledge [4].

The formation and functioning of innovation networks and systems that provide for an effective combination of hard-, soft-, and orgware can be problematic however, because of the existence of several gaps. With regard to the nature of these gaps, one can identify cognitive gaps (actors from different institutional backgrounds have too much cognitive distance to adequately learn together [11], or have different norms, values and incentive systems which hinder effective communication [12,13]), information gaps (actors are imperfectly informed about possible cooperation partners and what these can offer, i.e. there exists information asymmetry [14]), and managerial gaps (actors are unable to acquire and successfully implement new knowledge and technology [15]). Furthermore, there may exist a 'system gap', which is about the fit of the innovation within the broader system and is related to issues like path-dependency, dominant designs, and system lock-in [5,16,17].

In order to reduce these gaps, which may lead to innovation system failures in the form of network and institutional failures [18], and effectuate adequate combinations of hardware, software, and orgware, there is a growing attention for 'systemic intermediaries' who connect the different components of international, national, sectoral and/or regional innovation systems [16,19–22]. At the micro level, there is also attention for such intermediaries in the context of innovation network formation [23,24]. Often, such systemic intermediaries are at least partially supported with public funds (see e.g. [22,25,26]), as system failures provide a rationale for government intervention [27]. This implies that the role of government becomes one of a coordinator, as Hearn and Rooney [28] argue, which these authors specify as mediator, organizer, and transformer. Nooteboom [29] sees a role for government in the facilitation of cluster formation and innovation network formation. Braun [30] states in the context of science policy that the focus of government activities in general and of science policy in particular becomes not the manipulation of the behaviour of scientists but the creation of interaction spaces, the reduction of transaction costs for inter-systemic and interdisciplinary co-operation and the maintenance of vigorous, self-organizing systems. Edler and Georghiou [31] discuss both demand and supply side measures of government in respect of innovation policy tools. With regard to the formation of adequate innovation networks, supply side measures include what they call information and brokerage support and networking measures, and demand side measures include systemic policies (cluster/supply chain policies) and support of private demand (including articulation of demand, awareness, and training) as key innovation policy tools. As the subsequent review will show, systemic intermediaries appear to combine both supply and demand side measures.

1.2. Objectives and scope

The goal of this paper is to explore experiences with such systemic intermediaries that act as brokers in the formation and maintenance of innovation networks and systems, with a focus on their establishment and embedding. We focus on innovation intermediaries that have brokerage as their main task and, like Winch and Courtney [26], we call them 'innovation brokers'. This paper continues with a review of the literature in which such systemic intermediaries are described in the context of an innovation systems perspective, from different thematic angles. This review highlights the emergence of a type of systemic intermediary that is fully dedicated to the facilitation of the formation and maintenance of innovation networks and innovation systems from an independent third-party position. From this review, two lines of further empirical attention are identified: one which deals with the organization level effect of innovation brokers on the innovation process, and one which deals with the embedding of an innovation broker in the knowledge infrastructure and the innovation system. The paper aims to contribute to the second line of enquiry by providing a description of the emergence of different types of innovation brokers in the Dutch agricultural sector, and an analysis of their embedding. Although the literature has touched on this topic, it has often not been the central focus of analysis, whereas it is important from an innovation policy point of view as the number of innovation brokers appears to be steadily growing [32,33]. By mirroring it to experiences elsewhere, several problems and dilemmas are identified with regard to establishing innovation brokers sustainably as an innovation policy instrument.

2. Theoretical background

In view of an innovation systems and networking perspective on innovation, with an emphasis on the importance for innovation of connectivity of a heterogeneous group of actors and the importance of exploring and exploiting 'weak ties' [34], 'structural holes' [23] or 'interstices' [24], systemic intermediaries have been studied in a range of disciplines. These analyses have been made in relation to topics such as inter-firm networking and clustering [35,36], organizing regional innovation systems [19], the interaction between science establishments and industry [37–42], the transition to context sensitive, transdisciplinary 'mode 2' science [43], and large-scale societal transition processes [22].

Names often coined for such systemic intermediaries include third parties, brokers, bridging organizations, technology transfer intermediaries, -infrastructures or -organizations, and boundary organizations, but many other names are used. It is beyond the scope of this paper to attempt to describe all the different names attached to such systemic intermediaries (see [32]). Although there is a wealth of literature, this literature has been characterized as *theoretically fragmented and fairly practical* [33], and according to Howells [32] it is a *burgeoning, yet surprisingly disparate, field*. Recently, there have been several attempts to synthesize the broad but dispersed knowledge (e.g. [16,20,21,26,32]). By way of synthesizing the many existing definitions, Howells [32] employs the broad term 'innovation intermediary', which is defined as *An organization or body that acts as an agent or broker in any aspect of the innovation process between two or more parties. Such intermediary activities include: helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between, bodies or organizations that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaborations.*

In the literature, intermediaries that fulfill brokerage roles in innovation have been studied from different angles. These deal with their functions, the degree to which innovation intermediation or brokerage constitutes their organizational identity, their relation to the institutional environment, and their influence on the innovation process.

2.1. Innovation intermediation as a more or less central organizational identity: the innovation broker as a specialized intermediary

The provision of innovation intermediation functions may be more or less central to an organization's identity, and it may often not be their primary role as Howells [32] argues: *organizations providing intermediation functions do not solely or even wholly restrict themselves to intermediary functions, but also cover more traditional contract research and technical services which involve no third-party type collaboration*. For example, Pittaway et al. [44] found that 'science partners' play an important role as independent network brokers and intermediaries, and Dhanaraj and Parkhe [45] talk about a 'hub firm' fulfilling such a role in 'orchestrating' innovation networks. Apart from an external organization fulfilling innovation intermediation functions, the literature also provides examples of persons within (large) organizations fulfilling such intermediary roles as 'broker' or 'boundary spanner'. Such persons possess certain natural brokerage positions in the structure and the necessary personal qualities and competences for bridge building and mediation [23,24,46].

Although Howells [32] employs the broad term *innovation intermediary*, the definition of what it constitutes places the broker role quite centrally. Based on the dictionary definition, a broker *functions as an intermediary between two or more parties in negotiating agreements, bargains or the like* [36]. Following Den Hertog's distinction [47], those innovation intermediaries that have a broker role as their core function should hence be considered 'facilitators of innovation' (supporting an innovation process but the innovation neither originates from, nor is transferred by, the particular provider). This contrasts with other intermediaries that also pursue traditional, non-third-party activities that should be regarded as either 'sources of innovation' (playing a major role in initiating and developing an innovation) or 'carriers of innovation' (transferring an innovation that does not originate from the particular provider).

Winch and Courtney [26] note the establishment of such independent facilitators of innovation, focused on a particular industrial sector, and as mentioned in Section 1.2 have coined the term *innovation broker* for this type of dedicated innovation intermediary. This is defined as *an organization acting as a member of a network of actors in an industrial sector that is focused neither on the generation nor the implementation of innovations, but on enabling organizations to innovate* and they state that *such brokers represent an additional type of intermediary in innovation networks from those reviewed by Howells because their sole purpose is to act as a broker, rather than broking being a by-product of their principal activity*. With a similar perspective, Van Lente et al. [22] present a separation between 'traditional' innovation intermediaries, who often also are sources or carriers of innovation or are organizationally attached to sources of carriers of innovation, and 'new' innovation brokers who fulfill a more independent systemic role and adhere more to facilitation of innovation. Smits and Kuhlmann [16] state in this regard that *the traditional instruments [...] still take the individual organization, usually the business enterprise, or bilateral relations as the unit of analysis, hardly play a role as system builder and system organizer, do not pay much attention to learning processes, platforms for experimentation or tailor-made strategic intelligence and most of the time they focus largely on the private sector and far less on the public sector and public-private alliances*.

2.2. Innovation brokerage functions

In the literature a great number of functions are attributed to innovation brokers, and there is also much terminological redundancy and sometimes confusion [22]. Three basic functions can be seen [22,48]: 1) demand articulation: articulating innovation needs and corresponding demands in terms of technology, knowledge, funding, and policy; 2) network formation: facilitation of linkages between relevant actors (scanning, scoping, filtering, and matchmaking of possible cooperation partners); and 3) innovation process management: enhancing alignment and learning of the multi-actor network, which involves facilitating learning and cooperation in the innovation process. Johnson [20] describes broker functions in terms of roles and speaks about the roles of mediator/arbitrator, sponsor/funds provider, filter/legitimator, technology broker, and resource/management provider. The basic functions and roles are aggregates of several more detailed functions. Howells [32] made an extensive review of the existing literature and came to the following functions: foresight and diagnostics; scanning and information processing; knowledge processing and combination/recombination; gatekeeping and brokering; testing and validation; accreditation; validation and regulation; protecting the results; commercialization; evaluation of outcomes. Application of these different functions depends on different requirements of the innovation network in different phases of its development [49] and the composition of the network in terms of tie density and strength [8,26]. They are not necessarily applied in a linear fashion (e.g. it may be necessary to re-articulate demand and re-compose networks). As Howells [32] argues, these functions may be performed at different system aggregation levels: *in much of the discussion and analysis of intermediaries is that they operate in a simple triadic 'one-to-one-to-one' basis between, for example, a supplier and its customer in some kind of vertical relationship. However, in distributed innovation systems, intermediaries are increasingly involved in more complex relationships, such as 'many-to-one-to-one', 'one-to-one-to-many', 'many-to-one-to-many', or even 'many-to-many-to-many' collaborations, forming both vertical and horizontal relationships in increasingly distributed innovation networks*. These functions can hence be targeted at individual firms, and clusters or networks of firms, but can also be targeted at higher system aggregation levels in innovation systems that involve complex constellations of business, government, and societal actors, dealing with complex problems (i.e. 'system innovation'). This is what Smits and Kuhlmann [16] call *systemic instruments*. Innovation brokers hence contribute to several of the innovation systems functions that Hekkert et al. [17] have defined, most notably the functions *knowledge diffusion through networks, guidance of the search, resources mobilization, and creation of legitimacy/counteract resistance to change*.

2.3. Innovation brokers in relation to their institutional environment

The reasons why innovation brokers emerge are diverse, but generally they emerge in response to a perceived suboptimal degree of connectivity between relevant actors due to market or innovation system failures [16,20]. As Van der Meulen et al. [33] put it: *the establishment of an intermediary organization is often contingent on the specific political context or on typical opportunities*

and needs within research and innovation sectors. If the establishment results in ongoing interaction and a more enduring organization, the organizations will develop specific capabilities to mediate the relationship and we may observe institutionalization of relationships and development of structural positions. The literature provides examples of organizations specifically set up to exercise innovation brokerage (e.g. [16,20,26]), and also reports on the development of existing traditional intermediary structures into innovation brokers. This may imply that organizations traditionally involved in bilateral relationships, such as research councils, develop 'innovation agency' and become involved in multilateral relationships [43].

As regards this structural position of such an innovation broker, the literature identifies a number of central 'values' or 'design requirements' that are needed to maintain their position. A key premise of the facilitator role of innovation brokers is an impartial or neutral and independent position, i.e. that these do not adhere to certain preferred suppliers, network partners, or preferred development strategies [13,20,26]. In the context of the provision of innovation brokerage services to SMEs, Kolodny et al. [25] formulated a number of design requirements that they see as essential for the proper functioning of innovation brokers: (1) visibility and accessibility to SMEs, (2) trustworthiness to SMEs, (3) access to appropriate sources of knowledge and information relevant to the innovation process, (4) credibility of the intermediary organization with these sources, (5) quick response to the requests of SMEs, and (6) complementarity to the weaknesses of the SMEs it serves.

2.4. The influence of innovation brokers on the innovation process

Innovation brokers are seen to have a beneficial influence on the innovation process. In the context of inter-firm networking for example, which is seen as an important instrument for enhancing innovative performance [44], Malecki and Tootle [35] see brokers as *the spark plugs who guide the networks into existence*, and they are *the first sine qua non of networks*. They help to access the variety of tangible and intangible resources that are needed to realize an innovation [9,16]. Furthermore, they are also often the glue holding the network together by taking care of day-to-day network management issues, enhancing trust and resolving conflict [50,51]. At the innovation system level, innovation brokers create connectedness within the system, and have an 'animator' role of creating new possibilities and dynamism within a system, acting as a catalyst [16,32,52]. Innovation brokers contribute to reducing uncertainty in the early stages of innovation processes when there is a high risk of failure, which would preclude private parties from innovating [20,53]. However, Sapsed et al. [53] plead for more research in this respect, and state that *we lack an organization-level understanding of what makes bridging institutions effective in their role of compensating for weaknesses in a system*.

3. Lines of enquiry

Whereas now there is a good overview of the different innovation brokerage functions, and the range of organizations that may fulfill such tasks, there are several calls for more structural empirical analysis of innovation brokers. In this regard, two major lines of enquiry can be distinguished. One line deals with the position of the innovation brokers in relation to the innovation process, and with its functions and how these relate to particular stages in the innovation process. As mentioned in Section 2.4, Sapsed et al. [53] stress the importance of investigating the organization-level influence of innovation brokers. Several authors point at the importance of longitudinal analysis of how such brokers contribute to learning and experimenting in networks and innovation systems [16,21,22,37,54]. This line of research should also include analysis of the specific individual competences that staff of innovation brokers need to successfully fulfill their task, inspired by personal traits that are attributed to brokers and boundary spanners (see e.g. [46,55]). Especially knowing when to implement which innovation brokerage activity is a relevant question, as this is often defined only roughly. On the other hand, context specificity and reflexive modes of working are considered essential for innovation brokers [19,22].

The other line of enquiry deals with the types of innovation brokers that have emerged and how they fit in the innovation system, at different innovation system levels (i.e. (inter)national, sectoral, business chains, individual firms). Such research should include the stocktaking and description of innovation brokers [16]. Such an analysis could also provide information for a typology of different innovation brokers, and the degree to which they function uniquely as innovation brokers or also fulfill non-third-party type roles. Such an attempt to distinguish between traditional innovation intermediaries and new innovation brokers has for example been made by Van Lente et al. [22]. Since innovation brokers are a relatively new phenomenon, this calls for research on the relationships they develop with the broader innovation system for which they fulfill intermediation functions, especially with traditional parties in the knowledge infrastructure [22,32,52]. Van der Meulen et al. [33] suggest the following focus points in this regard:

- Configuration of relations in which the intermediary organization is involved, including also its resource position.
- Phases in the development of an intermediary organization, from its early development towards institutionalization and situations of crisis and institutional change.
- Competences and degree of independence of the intermediary organization, i.e. the degree to which it develops as an 'autonomous identity'.

This paper focuses on the second line of enquiry, by analyzing the emergence and embedding of several innovation brokers in the Dutch agricultural sector.

4. The emergence and embedding of innovation brokers in Dutch agriculture

The paper will now describe the emergence and embedding of several innovation brokers in the Dutch agricultural sector, and analyze these developments within the broader perspective that is provided by the literature. The data have been derived from

several studies by the present authors [48,56,57], and others [16,58] that have dealt in detail with this topic. For the agricultural sector, research on innovation brokers has been limited, but is growing. One reason for this may be that, traditionally, agriculture has been familiar with an intermediary layer between research and end-users (farmers) known as ‘agricultural extension’. This intermediary used to be publicly financed and had the goal of bridging the gap between agricultural science and farming practice [59]. However, agricultural extension became increasingly criticized as being part of a linear science-push innovation system. Recent policy changes such as privatization have caused the disappearance of this intermediary layer as a homogeneous entity. This implies that the situation in the agricultural sector with regard to acquiring knowledge and technology now resembles the situation of non-agricultural (e.g. industrial, service, retail) SMEs [60]. In the agricultural literature, innovation brokers have been mentioned in prospective and preliminary studies as possible solutions to innovation system failures [61–64], and there are some empirical studies that describe them [65,66].

4.1. *The emergence of different types of innovation brokers in the Dutch agricultural sector*

In the last two decades, large-scale transformations have affected the Dutch agricultural sector. The problems and challenges attached to this transformation are not confined to the Dutch agricultural sector, but have also emerged elsewhere in both industrialized and developing countries. They boil down to the following [4,59]:

1. Environmental and societal crises called for a transformation towards agri-food production systems that are ecologically, socially, and economically sustainable.
2. A shift from homogenous agriculture aimed at efficient and abundant food production, to diversification of products and services (multifunctionality of agriculture) or further specialization of producers, entailed a more heterogeneous knowledge demand. This has affected the interface between the users and producers of knowledge because tailor-made knowledge is needed.
3. The privatization of public agricultural knowledge infrastructures in the late nineteen eighties and early nineties. The emergence of a market in agricultural R&D and KIBS for the support of agricultural innovation processes has entailed a switch from supply-driven to demand-driven knowledge provision.

In Table 1 an overview is given of different types (labeled type 1 to type 7) of innovation brokers that have developed in the Dutch agricultural sector. These entities were mainly set up as, or have evolved into being, innovation brokers, i.e. facilitators of innovation. Often, innovation brokers cannot be easily classified under one category, as they are a hybrid of several functions. As Table 1 shows, innovation brokers have emerged at different levels of system aggregation, and wish to address different ambition levels of innovations (incremental, radical). They fulfill bridging and brokerage functions between different kinds of actors such as farmers, hardware suppliers (e.g. fertilizers, feed, machinery, packaging) and processing industries (e.g. dairy industry, food and fiber industries, energy suppliers), R&D (research institutes and universities) and KIBS providers (such as technical consultants, accountants, veterinaries, management consultants), government (national, regional), and civic advocacy organizations (e.g. on animal welfare, genetically modified organisms, environmental protection). In the context of the Dutch agricultural sector, the reasons for establishing such innovation brokers are of a diverse nature [16,56]:

- Policy driven, by both national and regional government policy. Stimulating innovation has received renewed attention in light of debates on the importance of innovation for competitiveness in the current knowledge economy. Innovation brokers are one of the new innovation policy tools of the Dutch Ministry of Agriculture, Nature, and Food Quality;
- Market- and/or innovation-system-failure driven, because actors involved in agricultural innovation feel that there are impediments that need to be overcome in order to arrive at concerted action to solve problems and tackle challenges facing agriculture. Whereas the public knowledge infrastructure used to be characterized by a high degree of interaction, the privatized knowledge infrastructure has become disintegrated. Market and system failures have emerged, such as information asymmetries, which hinder the setup of innovation networks;
- Resource-seeking driven, because traditional client–provider linkages have become corroded as a result of privatization of the agricultural knowledge infrastructure and there is a need to install new linkages for reasons of procurement;
- Driven by discussions on the changing role of science, as a response to the shortcomings of current systems of R&D and KIBS provision to adequately support entrepreneur-driven innovation and innovations that are socially acceptable and viable. Besides a shift towards demand-driven R&D and KIBS delivery, this required thinking outside the box and experimenting with novel ideas detached from prevalent agricultural production systems.

The reasons for setup are not mutually exclusive; this is partially explained by the fact that often multiple actors (i.e. public, private) are involved in the setup of innovation brokers. This corresponds with the previously cited observation of Van der Meulen et al. [33] that *the establishment of an intermediary organization is often contingent on the specific political context or on typical opportunities and needs within research and innovation sectors*. Also, in line with the hypothesis by the same authors that suggests that innovation brokers are dynamic with regard to their objectives, innovation brokers can change over time as a result of interaction with their environment. Therefore the original reason for its establishment can become obsolete as the innovation broker adapts to its environment.

For example, especially in the years after privatization of the public Dutch agricultural knowledge infrastructure, the motive of resource seeking has been a major reason for the establishment of type 1 and type 2 innovation brokers (see Table 1), as well as the realization of policy objectives. As a result of policy discussions, some kinds of innovation brokers may come into vogue. This is

Table 1

A typology of innovation brokers in Dutch agriculture (adapted from [48]).

Type	Functions	Comments	Coverage	Legal form	Funding	Innovation focus	Examples [#]
1. Innovation consultants aimed at individual farmers and agri-food SMEs	Demand articulation; Network composition: scanning, scoping, filtering, and matchmaking; Brokerage within established networks (innovation process management, i.e. enhancing alignment of actors and mutual learning)	Connect farmers/agri-food SMEs with relevant service providers (R&D and KIBS and 'hardware' suppliers), and also with sources of funding and policy information; Publicly funded organizations limited to demand articulation and matchmaking; Private organizations also fulfill brokerage within established networks (i.e. enhancing alignment of actors and mutual learning); Sometimes linked to science parks	Regional (province or sub-province level); Regional focus where coverage is national; Both sub-sectorally and cross-sectorally oriented	For-profit private firms; Quasi-autonomous government agencies; Non-profit foundations	Public funding through subsidies; Public/private funding through subsidies and/or shareholding; User payments	Innovations within individual enterprises; Generally incremental innovation; Short time horizons	Agricultural Knowledge Centre Noord Holland* Agricultural Knowledge Centre Flevoland*, Agricultural Knowledge Centre Zuid-Nederland*, Agricultural Knowledge Centre Zuid Holland*, Innovation Support Centre Wageningen*, Syntens Agro, Stimuland, LaMi, Agro&Co, Food Valley Innovation Link, Horti Solutions*, Poultry Centre, Croyeye, Innovation Support Point Zuid Limburg*, KnowHouse
2. Innovation consultants aimed at collectives of farmers and agri-food SMEs	Demand articulation; Network composition: scanning, scoping, filtering, and matchmaking; Brokerage within established networks (innovation process management, i.e. enhancing alignment of actors and mutual learning)	Connect farmers/agri-food SMEs with similar interests, and connect these with relevant service providers (R&D and KIBS and 'hardware' suppliers) and also with sources of funding and policy information	National; Regional (province or sub-province level); Regional; Both sub-sectorally and cross-sectorally oriented	Non-profit foundations; For-profit private firms; Quasi-autonomous government agencies	Public funding through subsidies; Private collective funding through subsidies; Public/private funding through subsidies and/or shareholding; User payments	Innovations relevant for groups of similar enterprises and in the context of a production chain; Generally incremental innovation; Short time horizons	KnowHouse, Agri-chain Knowledge*, Grower's Service Technology Department, Platform Agrologistics
3. Brokerage organizations that forge peer (inter-firm) networks	Demand articulation; Network composition: scanning, scoping, filtering, and matchmaking	Aim to bring farmers together to exchange knowledge and experience at the interpersonal and group level, i.e. enterprise development through peer-to-peer learning; Explicit objective is to involve actors from weak networks surpassing regional and sectoral networks), i.e. break out of 'strong-tie networks', avoid lock-in, and stimulate 'new combinations'	National; Sub-sectorally oriented	Non-profit foundations	Public funding through subsidies; User payments	Innovations relevant for groups of similar enterprises; Generally incremental innovation; Short time horizons	Poultry Centre, Dairy Farming Academy, Horticultural Cluster Academy, Pignet

Table 1 (continued)

Type	Functions	Comments	Coverage	Legal form	Funding	Innovation focus	Examples [#]
4. Systemic intermediaries for the support of innovation at higher system level (systemic instruments)	Demand articulation (including foresight); Network composition: scanning, scoping, filtering, and matchmaking; Research planning	Catalyst of system innovation role, by 1) the management of interfaces between (sub)systems, (2) building and organizing (innovation) systems, (3) providing a platform for learning and experimenting, (4) providing an infrastructure for strategic intelligence, and (5) stimulating demand articulation, and strategy and vision development. [16]; Involving several societal actors (e.g. farmers, supply and processing industry, civic advocacy organization, policy makers)	National; Sub-sectorally oriented	Non-profit foundations; Quasi-autonomous government agencies	Public funding through subsidies; Private collective funding through subsidies	Innovation at higher levels of system aggregation (entire production chain/ societal systems/policy systems); Generally radical/system innovation and transition trajectories; Medium to long time horizons	Courage, Greenhouse Horticulture Innovation Foundation, Innovation Rural Areas and Agricultural Systems, Transforum, Eggnovation, Germination Power
5. Internet-based portals and databases that display knowledge and information relevant to farmers and related parties	Network composition: scanning, scoping, filtering, and matchmaking	Portals differ with regard to their prospective audience: these may be all farmers or project-related audiences; Rather passive matchmaking role: portals create order in wealth of information sources and give an overview but do not serve as a selection aid	National; Sub-sectorally oriented with categorical subdivisions	Private for-profit firms; Part of publicly financed research and advisory projects	Privately funded if targeted at all farmers (user fees); Publicly funded if targeted at project-related audiences and other specific audiences	Broad range of links for addressing both operational or tactical problems and strategic innovation issues; Short time horizon	Agroportal, Knowledge On The Field (KODA)
6. Boundary organizations that act at the policy/research/user boundaries in research planning (i.e. research councils with 'innovation agency' [43])	Demand articulation; Brokerage within established networks (innovation process management, i.e. enhancing alignment of actors and mutual learning)	Management of multi-actor R&D planning networks (involving farmers, supply and processing industry, civic advocacy organization, policy makers); Facilitation of participatory/collaborative R&D (i.e. end-user participation)	Sectorally and sub-sectorally oriented	Non-profit foundations; Quasi-autonomous government agencies	Public funding through subsidies	Incremental and radical innovations; Short to medium time horizon	Transforum, Bioconnect
7. Boundary organizations that act at the policy/education/research interface	Demand articulation; Network composition: scanning, scoping, filtering, and matchmaking	Provide educational establishments with the latest insights from practice and research to enhance the fit of their education programs with business and societal needs	National	Non-profit foundations	Public funding through subsidies	Aimed at curricular innovation	Green Knowledge Cooperative, Content broker

*These organizations have ceased to exist.

[#] Names have been translated from Dutch where appropriate.

exemplified in the different kinds of academies (type 3) that have been set up recently to facilitate peer-to-peer learning because inter-firm networking emphasizing ‘the strength of weak ties’ has become popular [67]. It can also be seen in the establishment of sub-sector-oriented systemic foresight instruments based on the Innovation Network Rural Areas and Agricultural Systems (type 4) that has played an important role in the transition towards novel functions for agriculture and more sustainable production systems through applying creative destruction, out-of-the-box thinking, and hence making new combinations [16].

As regards the roles and functions that innovation brokers fulfill, as discussed in Section 2.2 of this paper, the basic functions of demand articulation, network formation, and the support of (multi-actor) learning processes (innovation process management) are similar throughout the different types of innovation brokers that have emerged in the Dutch agricultural knowledge infrastructure. However, they may vary with regard to the more specific intermediary functions executed, which in turn depend on the audience of the intermediary organizations, its systems aggregation level, its thematic focus, and its mandate. The mandate refers to the degree of involvement of the innovation broker in the innovation process, i.e. whether it is involved only at the beginning of the innovation process until a workable innovation network has been formed, or during the whole innovation process. This is especially relevant with regard to types 1, 2, and 3 innovation brokers as their functions most easily overlap with those of traditional intermediaries (such as existing KIBS and R&D providers). The mandate is again linked to the constellation of public and/or private actors involved in the setup and funding of the innovation broker, and the organizational structure chosen. There is a large variation, but the main organization forms are non-profit foundations, quasi-autonomous executive government agencies, and for-profit firms. Public agencies often act at a pre-competitive stage, i.e. until a network has been formed involving other (private) knowledge intensive service providers that fulfill certain innovation brokerage tasks besides being sources or carriers of innovation. Private companies who provide uniquely innovation brokerage (i.e. who act as third-party facilitators of innovation) often offer services throughout the whole innovation process.

4.2. *The embedding of innovation brokers*

Several studies in the Dutch agricultural context [16,48,56,58] indicate that innovation brokers are perceived to have several beneficial influences on the agricultural knowledge infrastructure and innovation system interaction. They act as innovation catalysts, by fulfilling the tasks of demand articulation (with different time horizons, levels of system aggregation, and complexity of innovation, i.e. incremental, radical, or system innovation), finding suitable cooperation partners in innovation processes (who may be both R&D and KIBS providers and other parties) and forging a connection with these actors, and facilitating interaction during the innovation process.

However, some tensions emerge with regard to the functioning and institutionalization of innovation brokers. Many of these tensions have to do with how the setup and the objectives of these innovation brokers fit within the established agricultural knowledge infrastructure. Van der Meulen et al. [33] observe in this regard that *the institutional development of intermediary organization may increase the capabilities to perform intermediary functions, but may also result in an increased institutional identity and a risk to lose impartiality*. The following tensions have been observed in the context of Dutch agriculture (see [48,56,57]), but, as reflection on the literature indicates, these appear to manifest themselves in other sectors as well; this would indicate that these problems are more general.

4.2.1. *A neutrality or impartiality paradox*

The neutrality or impartiality paradox, a term coined by Laschewski et al. [13], is about the observation that innovation brokers cannot be neutral or impartial because they always exercise a certain degree of steering (cf. even when they do not provide substantive knowledge themselves but act as a facilitator enabling interaction between actors). Some authors argue that their intervention is inherently non-neutral because the idea and strength of (inter-firm) networking are generally related to informal activities and personal relationships, but intervention is connected with a degree of formalization of structures and goals [12,13]. Such formalization may destabilize and erode the informal basis upon which networks are built. Furthermore, innovation brokers may set up networks that disturb existing structures [13], but, as Smits and Kuhlmann [16] argue, destruction of existing networks is sometimes also their goal to overcome lock-in. Many innovation brokers in the Dutch agricultural sector have such a ‘system revitalization’ mission. Some authors have found that an innovation broker may actively take a position and leave the neutral stance [68], but this would imply that *their existence remains limited to the lifecycle of the issues they represent in societal debate* [69].

Besides having to balance informal interaction and formalization of networks, innovation brokers need to balance different kind of demands addressed to them, and their accountabilities towards others, that have a direct influence on their present and future position [20,33,46]. Resource dependencies in particular, with an implicit or explicit expectation of return-on-investment, may force innovation brokers to exercise a certain amount of topical steering in demand articulation. Resource dependencies may also result in a bias in the matchmaking process (biased towards matching with certain parties). Achieving balance is especially complex in the case of mixed (public–private) funding of the innovation broker. Such steering by policy or procurement objectives threatens neutrality/impartiality and gives rise to a social dilemma situation in which the fulfillment of interests of individual financiers is given prevalence over the systemic contribution innovation brokers can make [48,56]. However, most innovation brokers attach much value to maintaining their neutrality/impartiality. They try either to ignore such pressures from financiers/other stakeholders, or to combine the different demands in a mutually acceptable solution. Because innovation brokers have to remain credible to all actors between whom they mediate, they have to balance short-term considerations and long-term considerations (i.e. building social resources that enhance future brokering flexibility [70]). They thus have to prevent themselves

succumbing to the pressure of a dominant financier and developing preferred partners to which they refer or whose development strategies they impose [13,48].

4.2.2. Functional ambiguity

Because innovation brokerage can be a function both of traditional knowledge intensive service providers (for-profit or not-for-profit) and of a dedicated brokerage organization [22,32,44], it is sometimes difficult for actors in the knowledge infrastructure and the innovation system to understand their position. As a result, in the Dutch agricultural knowledge infrastructure, innovation brokerage as an autonomous identity (according to Van der Meulen et al. [50]) has not yet been fully accepted [56,57]. This is partly due to the response from established players to the 'innovation system revitalization' mission of innovation brokers that disturbs configurations of established roles. It is also due to the overlap with existing or new functions of traditional R&D and KIBS parties (especially those functions that are applied when an innovation network has more or less materialized after initial demand articulation and network formation has taken place), which has also been observed elsewhere. Suvinen et al. [71] in this regard report a 'do it yourself' attitude amongst R&D providers, who wish to bypass such intermediaries. Candemir and Van Lente [52] in this sense state that they are sometimes perceived as 'noise' instead of bridges and catalysts of innovation. Innovation brokers may be perceived as taking up funds in a process that is achieved anyway [72], or as 'artificially' raising the cost of a project [56]. Hansson et al. [41] take an extreme position and even state that in the case of science parks: *We may in fact institutionalize and cement a low interaction between higher education institutions and industry. By creating these intermediary institutions we produce the illusion of bridging the gap between science and economy, while in fact such intermediaries contribute significantly to keeping the institutions of science and economy apart.* There is an irony in this: often, before their establishment, several parties in the innovation system see the need for a systemic agent and help set it up (guided by one of the previously described motives, see Section 4.1) but, once it has been set up, they sometimes do not know how to deal with it as it changes the usual routine. Also, an innovation broker's involvement may instigate institutional learning processes on the part of innovation brokers' clients (i.e. firms, KIBS and R&D parties) with regard to cooperation in innovation processes. This may result in innovation brokers being a temporary phenomenon that becomes eventually obsolete [48].

There appears to be a distinction with regard to pre-competitive and competitive functions (in terms of contracting services from traditional R&D and KIBS providers). On the one hand, the aggregated functions of demand articulation and network formation (i.e. scanning, scoping, filtering, and matchmaking) predominantly fall into the pre-competitive category. On the other hand, functions that belong to the category of the support of (multi-actor) learning processes (such as gatekeeping and knowledge brokering, i.e. bridging cognitive-cultural gaps) appear to belong more to the competitive category [56]. As a result of competing functions, innovation brokers may alienate themselves from players in the existing knowledge infrastructure who nevertheless can be important for network formation, as possible partners in the innovation network to be formed. However, this preliminary distinction may be very dependent on local circumstances and overall policy choices as to the design of the innovation support structure [25]. Furthermore, although some functions can be seen to be conflicting because they are also performed by traditional R&D and KIBS providers, actors may choose the involvement of an innovation broker because brokers can offer intermediation services in a more integral fashion and from a more neutral stance. Observation in the Dutch agricultural sector indicates that capacity and awareness building with regard to innovation skills and cooperation for innovation has taken place [48]. This includes the acceptance that an innovation broker fulfills the function of 'facilitator of innovation', which can have an added value vis-à-vis service providers that also have a role as a source or carrier of innovation. Nevertheless, combining these pre-competitive and competitive functions appears to require a considerable and continuous balancing act.

4.2.3. A funding paradox

There are various tensions relating to the funding of innovation brokers that give rise to a funding paradox. This means that, whereas innovation brokers wish to tackle various market and systems failures in the agricultural knowledge infrastructure, they suffer themselves from the same systems and market failures. Assessing the impact of innovation brokers is seen to be difficult, given their indirect impact on the business's value chain [7,32,48,54]. The difficulties apply in the case of both private funding and public funding. These tensions include:

- Difficulties in *ex-ante* evaluation of service value and low *ex-ante* identifiability of benefits that affect willingness-to-pay amongst private parties for, especially, functions that relate to demand articulation and alignment of actors and possibilities (network formation, i.e. scanning, scoping, filtering, and matchmaking). In the case of private funding of inter-firm network brokers, Huggins [12] found that, although firms in hindsight recognize the benefits and would be willing to contribute financially, they would not be willing to do this *ex ante* because of the high perceived risk of network failure. Bessant and Rush [15] speak in this regard of innovation brokerage as 'missionary work', and Göktepe [72] states in this context that *activities take place in the depths of the iceberg that one cannot easily see and evaluate.* This may result in a shift to providing services that are more marketable but entail moving away from the innovation broker's core function of facilitator and catalyst (cf. [73]) and/or competing with services provided by other parties, and hence carries the risk of the intermediary losing neutrality;
- Funding impatience [73]: public funding is provided for too short a period and this impedes the innovation broker from becoming well-established. This is enhanced by the fact that the impact of innovation brokers on innovation is hard to make visible with current evaluation methods [20,54,74]. Innovation brokers have difficulty in showing their impact in absolute terms: often evaluations stick to reporting achievements by using descriptive statistics, i.e. counting participants, activities, number of requests successfully processed, etc., and by measuring client satisfaction. It is difficult to calculate the effects of innovation brokers on innovation in terms of multiplier factors and spill-over effects, because of attribution problems. Private

investors withdraw funding when return-on-investment (implicit or explicit) is deemed insufficient [48]. This calls for the development of 'soft indicators' to measure activities such as network formation and learning [18,42,75].

- The manifestation of a social dilemma, in the sense that the systemic contribution of innovation brokers is recognized, but individual actors who benefit from the contribution innovation brokers make to the system's innovation capacity are hesitant to contribute long term to the brokers' funding without having a short-term return-on-investment.

In the context of innovation brokers in the Dutch agricultural sector, these tensions appear to be felt particularly by types 1, 2, and 3 innovation brokers (see Table 1). These innovation brokers offer services to optimize innovation at the level of the individual firm. In the case of this type of innovation brokerage, firms want to be sure they get value for money, and policy makers want to see justification for public spending. As regards types 4, 6, and 7, there appears to be more structural funding, because these innovation brokers work on complex problems that inherently bear a great risk of failure (type 4), or act as an arm's length representative for government (types 6 and 7). As regards type 5, because this type of innovation broker combines several ICT based functions (i.e. besides being a portal they may offer news, advertisement space, market research), they have several income-generating strategies.

As a response to these tension and pressures, and corresponding changes in organizational structure and funding arrangements, a continuous adaptation takes place with regard to the activities of the studied innovation brokers. This has resulted in the disappearance of some of them (see Table 1), and a shift amongst enduring innovation brokers towards activities that can be sustained under a certain funding regime. This often entails shifting from demand articulation and network formation, to innovation process management as well as providing 'technical' knowledge instead of facilitation. This may mean that they can shift from being a mere facilitator of innovation to being also a source and/or carrier of innovation. This has implications for their perceived neutrality, e.g. with regard to unbiased referral to other sources or carriers of innovation and as an unbiased arbitrator.

5. Conclusion: implications for policy

As Edler and Georghiou [31] indicate in their taxonomy of innovation policy tools, government has a number of tools at its disposal, of which the provision of innovation brokerage services is a device that combines both supply-side and demand-side measures. Innovation brokerage is seen in the general literature [16,32], as well as in the context of the Dutch agricultural innovation system, as having a beneficial influence on innovation by closing system gaps and acting as an animator or catalyst. Through innovation brokers, government may exercise its role as coordinator and mediator in innovation systems (cf. [27,28]).

However, as experiences in the context of the Dutch agricultural sector and elsewhere indicate, it is important to establish what the roles of government are with regard to innovation brokerage, and what the roles of the private sector are. There is a general agreement in the literature that publicly financed innovation brokers can fulfill the roles of demand articulation and network formation, but there are differing views on the involvement of such a publicly funded innovation broker when the innovation process is beyond its start-up phase. Caputo et al. [38,39] state that the intermediary organizations they observed play a substantial role in the management of the innovation process when an innovation network has been established, although Caputo et al. [38] speak about restricting this role to pilot projects: when the interaction between different actors in an innovation process is satisfactory, they withdraw. Kolodny et al. [25] state that it is a policy choice whether intermediary organizations should merely focus on third-party type brokerage functions or provide in-depth assistance with their own staff. In their study of technology extension organizations in seven countries, they observed varying scopes.

The analysis above offers a number of arguments to justify such a role for government as an innovation system coordinator and mediator, through the continued funding of innovation brokers:

- It appears difficult to make the basic functions of demand articulation and network formation self-sufficient.
- Innovation brokers contribute to systemic interaction and have a role as catalysts of innovation.
- Innovation brokers can more neutrally fulfill the role of facilitator (innovation process management) than parties that have a stake as sources or carriers of innovation in the subsequent research or innovation process.

Nevertheless, there are also some dilemmas in this regard:

- The justification for public spending on innovation brokers, as impact evaluation appears to be difficult. The effective evaluation of innovation brokers would require the development of indicators to measure 'soft' processes like network formation and institutional linkages emerging in the context of innovation (cf. [18]), and both qualitative and quantitative evaluation methods (cf. [74]).
- The proper demarcation of the mandate of publicly financed innovation brokers, because activities that go beyond demand articulation and network formation are sometimes perceived as competition by traditional R&D, KIBS, or other traditional providers of innovation brokerage services such as industry associations and chambers of commerce (see [22,56]). However, these activities are sometimes not yet performed in an integrated fashion by such traditional providers, or are perceived not to possess the same degree of impartiality. In this sense, Smits and Kuhlmann [16] propose the development of two 'network infrastructures': one that focuses on 'content' (i.e. linking relevant sources of information innovation processes into a structured whole, making it easier for actors to trace already existing information) and one that focuses on the process part (i.e. the support of multi-actor learning processes). Public innovation brokers could focus on the former, private innovation brokers on the latter.
- The risk that due to resource dependencies the innovation broker may become a more or less 'hidden messenger' for government or another party, which can be detrimental to its credibility and legitimacy. Government needs to realize that innovation brokers cannot be used as a directive instrument as they typically are involved in multi-stakeholder processes in which government may be one of the stakeholders and thus participates in an ongoing negotiation process.

As regards the emergence of the several types of innovation brokers in the Dutch agricultural sector, they do not appear to be the result of coherent policy. Rather, they have resulted from dispersed policy initiatives that in turn have been fed by general policy discourse. Recently, a more coherent policy with regard to public support for innovation brokers appears to have been developed, as policy documents indicate [76]. Several authors emphasize the need for coherence of innovation support instruments, both 'soft' instruments (awareness raising, demand articulation, networking support, consultancy, training) and 'hard' instruments (such as physical infrastructure, funding) [31,54,77]. Whether or not attempts to achieve more coherence will be realistic and effective, or will have unanticipated side effects (e.g. reduced location and context specificity and/or pro-activeness due to higher level efforts to streamline activities), will have to be studied at a later stage.

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