Philosophical Insights in System Modelling: An Application to the Field of Innovation Systems[1]

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Abstract

This paper argues for the need to establish a ‘dualistic’ philosophical approach to systems in system dynamics modelling. The example of a regional innovation system permits an investigation into the influence of philosophical perspectives on the analysis of systems, including decision-making processes and the implementation of policies identifying key influences. Results show that any dynamic regional innovation system, over time, finds it impossible to apply only one approach, with the result that the perception of its systemic problems and the corresponding managerial solutions are likely to change. Therefore, system dynamicists in the innovation policy area should pursue a dialectical policy of ‘thesis-antithesis-synthesis’, reflecting the ever-changing conditions within and around innovation systems.

Keywords: philosophy, system, system dynamics, regional innovation system

1. Introduction

System Dynamics (SD) is generally employed to discover the internal interactions and feedback processes that take place between diverse constituent factors within complex systems, and how changes in such elements cause expected or unexpected consequences within the systems modelled (Sterman, 2000). The concept of the feedback process, which lies at the heart of SD, has come from the cybernetic thread in biology and physiology and the servomechanism thread in economics and engineering (Richardson, 1999a). Modern SD initiatives, based on the servomechanism thread, started with a book entitled *Industrial Dynamics* written by J. Forrester (1961) and thereafter have been diffused throughout a number of fields, ranging from pure sciences to social sciences, and from mathematical areas to non-mathematical ones (Barlas, 2002; Richardson, 1999a; Schwaninger, 2006), especially management sub-arenas (Gary et al., 2008).

Despite its use in diverse fields, most of the distinctive strengths of SD are described in terms of their usefulness as a tool or methodology, involving areas such as graphical interface, modelling, computer simulation and application software (see Barlas, 1996; Barlas and Carpenter, 1990; Lane, 2000; Schwaninger, 2006), rather than as paradigmatic for problem-solving in management sciences. Furthermore, paradigmatic philosophies related to 'the concept of systems' are not routinely treated by SD practitioners. Their focus largely remains on philosophical approaches to internal mechanisms of circular causalities and feedback loops (see Lane, 2000; Morecroft, 1983; Rafferty, 2007; Schwaninger, 2006; Vázquez and Liz, 2007).

The lack of a clear paradigmatic philosophy in SD is likely to generate misleading perceptions with regard to the role of a system at different levels—whether individual and family levels, organisational and societal levels or more complex technical systems levels (Schwaninger, 2006). Since systems are the observing target of SD, the means of observing, constructing, analysing and interpreting their dynamic internal properties will vary according to perceptions of such systems. It is thus necessary to consider what philosophical insights influence the view of a system before investigating the internal dynamics of the system. We believe that the investigation of the philosophical discourses affecting the perceptions of a system is an important initial point in any SD activity.

While general philosophical investigations of SD have been attempted, some claim that there is a need for dualistic approaches to link different, or indeed opposite, philosophies such as constructivism and reductionism (Schiere et al., 1999), holism and reductionism (Rafferty, 2007), constructivism and expressivism (Vázquez and Liz, 2007), and interpretivism and positivism (Schwaninger, 2006) to obtain a clear paradigmatic philosophy of SD.

In line with these proposals regarding dualistic approaches, we employ a cross-disciplinary viewpoint of a 'system' itself as the observing target, rather than the methodological focus of previous researchers. The paper is structured in the following way. We consider the need for philosophies in SD prior to justifying the synthetic philosophical views. Following this, we review and summarise existing SD-related philosophical insights within a system. Then, we illustrate our ideas using the concept of regional innovation systems.

2. The necessity for philosophy in SD

SD is mainly understood as a tool and a methodology for simulating complex systems (see Barlas, 1996; Barlas and Carpenter, 1990; Lane, 2000; Schwaninger, 2006), rather than as a

paradigm for problem solving (Morecroft, 1983). Indeed, it may appear somewhat unusual to consider SD simultaneously alongside philosophy, since SD belongs in the sciences, whereas philosophy principally resides in the humanities. However, while scientists attempt to be completely rational in data collection and their observations in order to test theories or assumptions, they are not 'unbiased observers' of phenomena; rather, they are fallible beings (Woodward and Goodstein, 1996). Scientists obtain, produce and apply subjective data, theories and principles whereby 'science' is formed (Ratzsch, 1996). In particular, scientific 'observations' cannot be totally objective or neutral, either theoretically or practically (Shapin, 1982). Consequently, philosophical insights and their impact on SD have to be considered, to enhance the thoughtful practice of system dynamicists and to gain theoretical recognition for SD from outside the SD community.

From the perspective of system dynamicists, in the process of systemic problem generation, philosophical thinking is necessary for the description of the internal behaviours of a system. Modelling a complex system starts by building its structure (Dash, 1994; Sterman, 2000). A system is defined within a structured entity and includes elements and their dynamic behaviour over time. The structure determines the behaviour affecting the properties of the system, such as level, rate, delays, physical flows, information flows, feedback loops, and its performance. Therefore, subjective logic, the so-called philosophical perception of a system, is embedded within the SD activity and involves aspects such as seeing, building, analysing and interpreting the system when it is modelled. System dynamicists' mental models, insofar as they are affected by their judgement and contexts, determine the insights observed in a system and produce 'subjectively objective' observations, models, interpretation, analysis and actions with regard to a system (Doyle and Ford, 1998; Lane, 2000). Therefore, the way in which a system is observed, coupled with its structure, determines the expected behaviour and the purposeful consequences of the system. Consequently, there is always a latent impact by philosophy on SD.

In an attempt to confirm SD as a paradigm in problem-solving areas, a philosophical perspective is required to enable SD thinkers to communicate with outside experts (Morecroft, 1983)[2]. Apart from Richardson (1999b), the term 'paradigm' has often been used to implicitly conceptualise SD in systems thinking (see Andersen, 1980; Barlas, 2002; Barlas and Carpenter, 1990; Gregoriades and Karakostas, 2004; Levine, 1983; Meadows, 1980; Meadows and Robinson, 1985; Morecroft, 1983; Schwaninger, 2006), without reflecting Kuhn's (1996) philosophical theorisation of the requirements of paradigm formation. To satisfy Kuhn's requirements, external communication into other fields will be necessary to get others to acknowledge the potential and usefulness of SD. Concerning this, Morecroft (1983) says, 'Without a clearly communicated philosophy there is nothing to separate the subject from the simulation technique it uses'. Thus, it is necessary to prove the successful philosophical positioning of SD within problem-solving areas for more prevalent use, greater acceptance and theoretical recognition of SD in a wide range of domains.

In short, philosophical features are not a separate subject divorced from problem-solving processes in SD; rather, they are a means to seriously improve the practices of dynamicists. Moreover, the recognition of SD as a paradigmatic theory necessitates philosophical arguments to convince outside problem solvers.

[2] Morecroft (1983) uses the term 'philosophy' in an unusual way but since the term is employed to express SD's own doctrine, which can separate SD from other problem-solving approaches, his 'philosophy' is acceptable as a form of philosophical principle.

3. Previous investigations into the philosophy of SD

Aside from the few studies on philosophies about 'systems' mentioned above, most philosophical thinking within SD focuses on procedures, methodology and the internal causality and feedback of SD (see Lane, 2000; Morecroft, 1983; Rafferty, 2007; Schwaninger, 2006; Vázquez and Liz, 2007). Even though early SD has been defined as a positivist methodology characteristic of a servomechanistic approach within the social systems (Lane, 2001) or else as a constructivist methodology (Richardson, 1999b), the range of philosophical interpretations of SD is truly vast. This paper reviews some attempts that touch on SD and its philosophies, prior to asserting the need for a dualistic view of a system.

3.1. Constructivism and Reductionism

The distinction between reductionism and constructivism in SD is determined by the extent to which variable contexts and observers in and around a system are considered. Schiere et al. (1999) pay more attention to constructivism in SD and object to reductionism because it focuses on the functionality and achievements of fragmentary systems. Reductionism is a conservative view (Schiere et al., 1999) because it defines a system as an agglomeration of interdependent elements organised into a meaningful whole as a way of achieving its purpose (Barlas, 2002). In a reductionist view, the purpose of a system is the common goal that its components should jointly achieve, which tends to be fixed without taking variant contexts and observers into consideration. Thus, the perspective of reductionism does not take into consideration to a significant extent changes in internal properties, such as inputs, outputs and parts of a system. On the other hand, in an early work of Richardson (1999b), SD is regarded as constructivist. From the perspective of constructivism, the clearly fixed goals of a system do not exist, but flexibly changeable objectives do (Campbell, 1996; Renting et al., 1994; Roberts and Coutts, 1997). With this in mind, constructivism conceives of a system as an entity that is sensitive to the change in its properties (Spedding, 1995).

3.2. Holism and Reductionism

Whether SD is characterised by holism or reductionism depends on the extent to which the range of a system is covered. Holism is a means of conceptualising a system as 'more than the sum of its parts' (Baranoff, 2004; Hofstede et al., 1993; Jackson, 2005; Roberts et al., 2002), whereas reductionism is the view of a system as 'the sum of its parts' (Popper, 1979). The focus of the former stance is on the whole entity, rather than the constituent elements, in a top-down way, so that the understanding of a system is from the whole to the part and there is no need to consider the individual parts of the system. Thus, feedback problems are regarded as problems of the entire system, not sub-problems of its elements. By contrast, the latter approach, which regards a system as merely the sum of its parts, mainly focuses on the roles and functions of the parts rather than those of the whole, so that different sub-problems in the different contexts of each element gain more attention, employing a bottom-up perspective. This approach thus resolves systemic problems by breaking them down into several constituent sub-problems. In Rafferty's (2007) work, SD is a reductionist approach, regarded as a tool and a methodology, whereas for Sterman (2000) and Towill (1993), holistic insight begins with a conceptual model and ends with a system dynamics model, reductionism being the complete opposite.

3.3. Constructivism and Expressivism, and Interpretivism and Positivism

Following Vázquez and Liz (2007), expressivism operates along the lines of constructivism, whereby the subjective mental models of observers and variant contexts derive flexible, pragmatic, inferential and contextual interpretations of systems. That is, social phenomena and systems are viewed in different ways, according to the normative restrictions of a peculiar social context. By accepting the notion of subjectivity, this synthetic approach accompanies a 'dualistic' application of epistemological and ontological insights into a system (Lane, 2000; Vázquez and Liz, 2007). In other words, social systems are viewed as epistemologically objective entities and ontologically subjective entities, and SD systems present explicit structures of corresponding social systems while deriving implicit meanings from those social systems. The meaning of a system as a symbol is subjectively interpreted in different philosophical ways.

A system can also be considered in the light of interpretivism and positivism (Schwaninger, 2006). Interpretivism emphasises the subjective construal of occurrences, whereas positivism is used to discover 'objective' knowledge characterised as 'facts'. The former is generally associated with holistic, constructivistic and expressivistic approaches, whereas the latter is generally connected to a reductive and deterministic approach to information about a system. An interpretivistic stance treats a system in SD modelling as a flexible object that can be perceived differently in accordance with the contexts in which different philosophical insights exist. By contrast, a positivistic stance imposes the observing target on roles, responsibility and position so that a system is merely regarded as a constituent facilitator of the whole, regardless of heterogeneous philosophical insights into the system.

3.4. A synthetic dualism of philosophies

In many circumstances, the word 'dynamics' involves a feature of some 'uncertainty' in nature or turbulence over time, which demands flexible managerial approaches (Barlas, 2002), so that multifaceted insights into systems are sometimes necessary. The possibility of a dualistic approach opens the door to the possibility of succeeding where independent and separate philosophical approaches have failed.

Pluralistic viewpoints deal with multiple realities rather than assuming that there is just one objective truth for a system (Jackson, 1999). Although Rafferty (2007) concludes that SD adopts reductionism in practical situations, an approach to systems offering a more flexible doctrine and containing two contrasting ideas is a possibility, given that a system is frequently conceived as a holistic entity (see Hofstede et al., 1993; Roberts et al., 2002). This approach would accept the dichotomous insights into a system offered by holism and reductionism and simultaneously attempt to compromise with both (Rebernik and Mulej, 2000). According to Lane (2000, 2001), systems approaches, including SD, simultaneously possess antithetical characteristics (Schwaninger, 2006), and Luyten and Hoefnagel (1995) suggest a combination of multiple paradigms facilitating the coexistence of diverse viewpoints in SD and plural philosophical insights into a system.

In SD, it is thus acceptable to apply multiple philosophical approaches to the pragmatic perception of systems according to the contexts and observers of a system. All preceding investigations thus constitute a moment of 'synthesis', to use the dialectical 'thesis-antithesis-synthesis' model, of opposed philosophies.

3.5. Summary

Looking into the philosophies discussed, we divide their insights into a system based on the distinctive features of a system according to philosophical doctrine: main object, logical stream, system definition, problem definition, goal definition, context and observer variability, sensitivity to changes and interpretation flexibility.

We group the disciplines of observing a system into 'constructivism, interpretivism, holism, and expressivism', 'reductionism and positivism', and 'dualism'. 'Dualism' is a synthesis of the two philosophical groups, where we believe SD practitioners feel more comfortable. A comparison of these different perceptions is presented in Table 1.

Table 1 Summary of philosophical approaches to system analysis

	PHILOSOPHY		
	Constructivism, Interpretivism, Holism and Expressivism →	**Dualism**	← **Reductionism and Positivism**
CRITERIA			
Main Object	A whole system	Whole or sub-system(s)	Constituent elements
Logical Stream	Top-down	Top-down or bottom-up	Bottom-up
System Definition	More than the sum of parts	More than or just the sum of parts	Just the sum of parts
Problem Definition	A whole problem of a system	Whole or sub-problems of a system	Sub-problems of elements
Goal Definition	No common goal	Non-common or common goals of sub-systems	Common goals of components
Context and Observer	Variant context and observer	Variant or static context and observer	Static context and observer
Sensitivity to Changes	Sensitive to the changes in internal properties	Sensitive or non-sensitive to changes of internal properties	Not sensitive to the changes in internal properties
Interpretation Flexibility	Flexible, inferential, pragmatic and contextual	Flexible or inflexible, inferential or concrete, pragmatic or ideal and contextual or contextual	Inflexible, concrete, ideal and non-contextual

As can be seen in Table 1, 'constructivism, interpretivism, holism and expressivism' (in the left column) and 'reductionism and positivism' (in the right column) are placed in opposition to one another, whereas 'dualism' (in the middle column) adopts a 'go-as-you-please' approach. That is, 'dualism' is not simply bound by one or other of the two philosophical poles.

4. Discussion: Philosophical insights applied to innovation systems

4.1. National and regional innovation systems

Since the 1950s, national approaches have focused on improving the economic value of knowledge, broadening the use of systematic approaches and stimulating knowledge creation (Edquist, 1997; Freeman, 1995; Lundvall, 1992; Nelson, 1993). This caused serious disparities between regions with regard to profit creation, business attraction and infrastructure (Meyer-Krahmer, 1990). Many researchers and policymakers have pointed out certain limitations: national innovation systems (NISs) were so broad that it was difficult to understand and clearly manage the relative dynamics of different technology systems in several regions (Metcalfe, 1995). For this reason, it has been suggested that the focus should be on institutionally localised technology-based systems, so-called regional innovation systems (RISs).

4.2. Mental models, systemic problems and perception of an RIS

The conceptualisation of an RIS provides lessons for SD practice in dealing with the dynamics of systems to develop strategic policies for regional innovation. Under the concept of the mental models of decision makers (Doyle and Ford, 1998; Lane, 2000), philosophical conceptions form the mental models of policymakers and implementers of regional innovation development programs, affecting their observations, analysis, interpretations and managerial actions in RISs.

Different mental models for the observation of a system are exposed to conflicting ideas and goals. The sentence ‘Beauty is in the eye of the beholder’ (Schiere et al., 1999) highlights the fact that the features, purpose, usefulness and interpretation of a system vary in accordance with the ‘context’, depending on who is looking at the situation and what is happening (Röling, 1996). Thus, the context-based perception of a system is explained by the ‘mental models’ of the owners (Doyle and Ford, 1998; Forrester, 1961, 1971; Lane, 2000; Morecroft, 1994; Röling, 1996; Schiere et al., 1999; Senge, 1990; Sterman, 1994; Vázquez et al., 1996), affected by their philosophical approach.

In terms of the configuration of innovation systems, efficient RISs establish a competitive NIS (Chung, 2002), an RIS being a local unit where innovation actors build interactions to produce, diffuse and employ knowledge more efficiently in technologies and products or services (Braczyk et al., 1998; Cooke and Schienstock, 2000; Doloreux, 2003; Edquist, 1997; Gertler, 2003; Isaksen, 2001; Nauwelaers et al., 1995). Each company’s competency contributes to overall regional competency. In addition, RISs are the units that comprise an NIS, and therefore the aggregate innovation of RISs should be regarded as the entire innovation engine of an NIS. This hierarchical view can be reconstrued by understanding the generative process of new systemic problems through a feedback problem-solving process in SD, as shown in Figure 1.

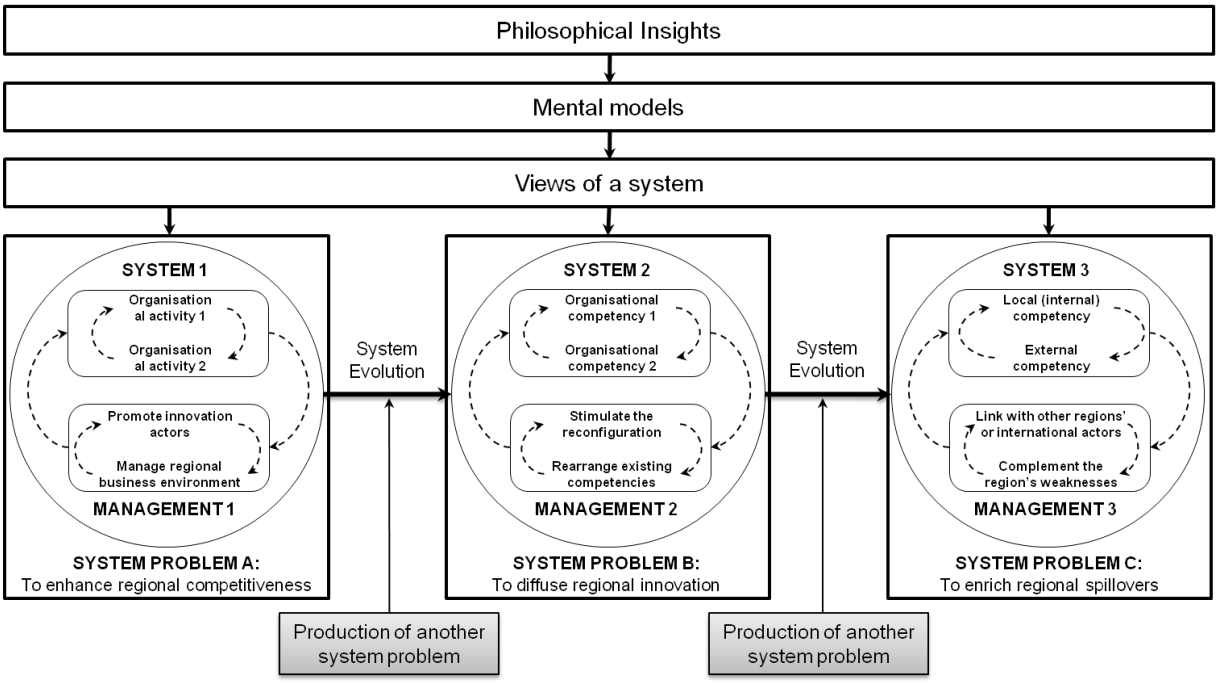

Figure 1 Different views of an RIS generated by different philosophical insights in the process of systemic problem generation (based on Barlas, 2002)

Systemic problems are generated from feedback problems between managerial measures and their impact in a system, and between diverse constituent parts in the system. However, other systemic problems are born during the process of understanding feedback problems and in taking action to solve the problems by manipulating controllable internal properties (Barlas, 2002). A new challenge potentially demands a new definition of another system, and the emerging system recognises the new challenge as part of the feedback processes. Concerning the dynamic relations of an RIS with other systems—an NIS, other RISs and its constituent sub-systems—the philosophical insights based on mental models of contexts and observers are not merely related to the hierarchical position of an RIS but also remain highly relevant to the field of regional innovation policies, such as defining a system, observing systemic problems and taking managerial action.

For instance (see Figure 1), the first systemic problem within an RIS starts with the main purpose of the innovation system, which is to promote the innovation activities of local actors within a certain region by considering the unique business environments of the area (System Problem A) (Herstad and Brekke, 2012). In the regional focus, managers attempt to enhance specialised knowledge based on regional corporate activities and networks (Giuliani and Bell, 2005), regional industrial structure (Boschma and Iammarino, 2009), and regional mechanisms, knowledge flows and synergistic activities (Herstad and Brekke, 2012). During the process of solving System Problem A, the need to maximise the agglomeration effect of various corporate competencies within the location arises in order to diffuse regional innovation, by rearranging competencies and stimulating the reconfiguration (System Problem B) (Cooke, 2007). Then, the problem-solving process related to System Problem B brings an additional argument about the enrichment of regional spillovers of local innovation actors, by linking with other regions' actors or even international actors and complementing the region's weak competencies (System Problem C) (Graf, 2011; Herstad et al., 2010).

Using an SD perspective (see Figure 1), regional government support promotes innovation activities (e.g., product development) of local constituent sub-systems (e.g., firms) in the process of solving System Problem A. The intention is to build up the stock of individual competencies (e.g., product innovation capability) of local innovation actors and to increase the overall (or average) stock of regional competencies within a certain area. However, the effect is not similar across all firms in the region. Therefore, System Problem B is solved when the competencies stocked in each local actor are shared with other local organisations (e.g., other firms, universities, etc.) through competency reconfiguration (e.g. outsourcing, collaboration, etc.) diffusing a regional innovation. Finally, System Problem C, which aims to enrich regional spillovers of local actors, is addressed, linking competencies located inside and outside of an RIS. The information and knowledge flows of local competency spillovers are enhanced by importing outside competencies (e.g., purchasing Six Sigma machines or methods from Japan) or by exchanging competencies (e.g., co-production of Samsung and Sony) across regions or even countries.

On the basis of the impact of mental models on the decision-making process from the perspective of SD, the different viewpoints of an RIS are likely to affect the approaches employed to tackle feedback problems, the corresponding actions to control the problems, the emergence of new systemic problems and the new arrangement of an emerging system in the regional innovation policymaking process. The focuses of the three different systems in Figure 1 are on innovation activities of local actors (System 1), regional effect of local innovation actors (System 2) and synergistic effect of internal and external innovation actors (System 3). Such a distinction is contingent on diverse mental models of an RIS—appropriate to the aims of problem owners and the focuses of feedback problems—and the influencing range of an RIS. In short, the approach employed to analyse an RIS generates different views of systemic problems in a region requiring different managerial actions and seeing the emergence of other systems and problems.

4.3. Region-oriented, nation-oriented and region-nation synthetic views

In analogising the general perception of a system, determined by the classification of philosophical approaches in Table 1, the philosophical perception of an RIS can be described in three different ways:

First of all, **a region-oriented view,** based on constructivism (Schiere et al., 1999; Vázquez and Liz, 2007), interpretivism (Schwaninger, 2006), holism (Rafferty, 2007), and expressivism (Vázquez and Liz, 2007). This approach sheds light on a region itself as the unit of analysis while imposing innovation functionality on local innovation actors. An RIS is regarded as a whole system that ideally attains concrete aims by dealing with regional innovation problems as overall systemic problems for the local competitiveness of each area. Because of the concentration on a specific geographical place, the regional innovation agendas of local governments act in a top-down manner, so that an RIS considers more regional short-term schemes rather than nationwide innovation approaches. In addition, a region-oriented perspective regards an RIS as a self-regulating innovation mechanism, which operates flexibly under normative national innovation policies, according to the variable contexts of each region.

From the perspective of SD, systemic problems in an RIS are specific to a region. For this reason, the issues between feedback problems and the managerial actions emerging from the problem-solving process are located within the localised environment. This feature minimises the influences of nationwide innovation policies on self-contained regional innovation plans. Moreover, a region-oriented view is characterised by the top-down

innovation policies of local authorities to advance regional competitiveness, synergistic effects between local innovation actors, high sensitivity to the status of innovation activities within the region and active responses to changing regional contexts.

By contrast, the perception of RISs in **a nation-oriented view** is based on reductionism (Rafferty, 2007; Schiere et al., 1999) and positivism (Schwaninger, 2006). The focus of this view is on the priority of national innovation, based on the functionality of each region. It sees local systems as constituent units that compose an NIS in order to achieve national common goals, rather than each area's objectives. That is, an NIS is a place where the innovation activities of constituent RISs happen, and its development is the sum of the consequences of localised innovation. Nationwide regional efforts are implemented so as to retain national mid- and long-term agendas in a bottom-up manner. Moreover, in terms of a nation-oriented view, RISs are explained as invariable self-regulating mechanisms, controlled and fixed by mega contexts and formed by dominant national innovation policies.

With regard to SD insights, this view focuses on the nationalised functionality of an RIS, such that feedback problems of RISs and the managerial measures raised during the problem-solving process are likely to be conceived as new challenges for an NIS and other RISs. In view of this feature, innovation policies at the national stage tend to affect and control the innovation schemes of the constituent RISs. That is, the nationwide mental models of innovation systems lead to uniform views of regional 'beholders' by providing RISs with common goals. Hence, the solutions to systemic problems and the development achievements of regions tend to be fixed without considering the specifics of each RIS. A nation-oriented view requires bottom-up innovation support from at the regional unit level. Consequently, an RIS is insensitive to innovation status in particular contexts within regions and does not consider the regional agglomeration effect caused by innovation actors.

Along with the two approaches above, a third might be suggested, namely, a **region-nation synthetic view***.* This is the result of mixing region-oriented and nation-oriented approaches. Such a view adopts a dualistic perspective, incorporating diverse philosophical insights into a system (Jackson, 1999; Lane, 2000; Luyten and Hoefnagel,1995; Rafferty, 2007; Rebernik and Mulej, 2000; Schiere et al., 1999; Schwaninger, 2006; Vázquez and Liz, 2007). Accordingly, an RIS is thought of as an intermediate entity, which is connected to an NIS and other RISs. That is, regional innovation is led by the innovation activities of sub-systems within the area, and the dynamic properties of corporate and supportive innovation activities over time lead to the dynamics of regional innovation and competency.

In terms of SD thinking, the relationships between regional systemic problems and national systemic problems are depicted in a region-nation synthetic view. Feedback problems that take place in an RIS, and problem-solving actions, are simultaneously seen from two opposite directions: an RIS-oriented mental model and an NIS-oriented mental model. According to particular regional innovation schemes, mental models of viewing an RIS, its feedback problems and required managerial actions, are likely to be differentially applied, so that the influencing boundary varies from being purely within an RIS to extending across the NIS and other RISs. From the perspective of the 'beholder of beauty', the eyes of the beholder can be raised to nationwide innovation but can also see region-based innovation. Thus, different innovation processes matter, and central government should employ flexible interventions or self-contained innovation plans for regions. It can rely on regional schemes aimed at fixed common goals given by NIS features or regionally specific objectives given by RIS features. While the focus of NIS features is on the individual functionality of each RIS to achieve uniform nationwide goals and avoid regional disparities, regional features pursue synergistic effects between local innovation actors so as to achieve a region's objectives, considering the local contexts of the internal innovation dynamics.

The three philosophical conceptions of an RIS are summarised in Table 2.

Table 2 Three conceptions of an RIS

	Region-oriented	Nation-oriented	Region-nation Synthetic
Philosophy	Constructivism, interpretivism, holism and expressivism	Reductionism and positivism	Dualism of philosophical threads
Main Object	RIS as a whole system	A nation-dependent constituent unit	Flexible observing target
Logical Stream	Local government's top-down innovation policies for regional short-term achievements	Local government's bottom-up innovation policies for a national mid- and long-term agenda	Mixture of local government's top-down policies for regional objectives and bottom-up policies for national goals
System Definition	More than the aggregation of local innovative actors	Just the sum of local innovative actors	Flexible definition of the scale, range, and roles of a RIS
Problem Definition	Regional innovation problems/challenges as a whole system	Sub-problems of regions affecting national innovation problems/challenges	Flexible definition of the influencing range of problems and required solutions
Goal Definition	Regional development as an ideal goal of a local unit	Sub-objectives of regions to achieve an ideal whole development of a nation	Flexible goal definition
Context and Observer	Variant innovation contexts and localised innovation views of a region; self-regulating innovation mechanisms in a big picture of national innovation policies	Fixed innovation contexts and localised innovation views of a region; innovation mechanisms tied within given national innovation policies	Flexible variability; flexible construction and operation of innovation mechanisms
Sensitivity to Changes	Sensitive to the changes of local innovation properties	Not sensitive to the changes of local innovation properties	Flexible sensitivity level to the dynamics of regional innovation properties
Interpretation Flexibility	Context-based flexible political response to variable regional situations	Non-context-based static political response to given national innovation policies	Variant flexibility of response to contexts around a region

It should be noted that philosophical dualism adopts an external perspective on an RIS, whereas constructivism, interpretivism, holism and expressivism adopt a perspective internal to it. In other words, the former situates the RIS in relation to an NIS and other RISs, whereas the latter approaches refer to the internal context of each RIS. Thus, dualistic insights are employed to view the observing target in the flexible contexts in which an RIS is located.

Different priorities in an RIS, according to mental models, bring about different directions and focuses of innovation policies. For example, different positions of government bodies show different priorities in regional innovation and technology measures. Central governments give more importance to nationwide systemic problems and so focus on support institutions for large companies in order to attain national goals (a nation-oriented view), whereas regional governments tend to focus on local problems in order to achieve their specific objectives (a region-oriented view) (Altuzarra, 2010). Likewise, in the example of farming

systems (Schiere et al., 1999), policymakers tend to enact innovation laws so as to concentrate on long-term-oriented nationwide development (a nation-oriented view), whereas local organisations and residents prefer short-term regional achievements (a region-oriented view). Such a debatable issue may be understood in terms of the philosophical conflicts between different perspectives generated by different mental models of an RIS, and it is obvious that at times the problem-solving process triggers new political conflicts and clashes between interest groups that favour regional innovation in each area.

Bearing this in mind, for system modelling in the field of innovation systems, it is clear that the philosophical perception of an RIS and its feedback problems imply various position with regard to observing, modelling, analysing and interpreting a system. Along with mental models determining diverse system modelling approaches in the innovation policy field, the necessity for a dualistic stance (a region-nation synthetic view) is supported by the idea that, '[t]here is good reason to think that policy can make a very big difference to regional development and yet at the same time it is very hard to know exactly what the right policy is'. (Krugman, 2003). In brief, the human subjectivity (or preference) of problem solvers or system modellers and the uncertainty inherent in policy areas require a dualistic philosophical view of an RIS, appropriate to the situations in which the system is observed.

5. Conclusion

This paper has explored system modelling through two practical questions: 'How should a system be observed?' and 'How do philosophical insights influence the view of a system?' While the philosophical literature on SD has largely focused on a methodological analysis and on the internal dynamics of a system, this paper has considered the philosophical aspects of systems themselves in terms of the paradigmatic practice of SD. Philosophical thinking provides a fertile grounding in SD for system dynamicists to implement a more thoughtful problem-solving process, and for outside experts to acknowledge SD as a paradigm for the management sciences.

Concerning the contrasting views of systems, this paper advocates a dualistic approach that reconciles opposing philosophical positions: those of 'constructivism, interpretivism, holism and expressivism' on the one hand and 'reductionism and positivism' on the other. The validity of dualism arises from the diverse insights it offers into systems and their feedback problems, diverse because of the mental models applied to the given dynamic contexts in which systems are located. Systems need to be treated and thought about in ways appropriate to their context.

In the case of an innovation system, SD may provide policymakers with self-fulfilling prophecies; the philosophical views of a system remain highly influential in defining and observing systemic problems in the innovation systems and in developing and implementing managerial regional innovation policies. Philosophical perspectives enable decision makers to gain a broader insight into an RIS at national and regional levels stances at the same time, but a dualistic way of thinking provides the practical possibility of establishing a link between philosophical insights into and mental models of an RIS and SD policymaking, supporting the implementation process within regional innovation policies.

The general perception of an innovation system according to philosophical themes is applied through three insights: 1) 'a region-oriented view', based on constructivism, interpretivism, holism and expressivism; 2) 'a nation-oriented view', based on reductionism and positivism; and 3) 'a region-nation synthetic view', based on a dualistic approach and employing multiple philosophical threads. The first two views give innovation priority to a regional unit

and a national unit, respectively, whereas a region-nation synthetic view is concerned with the synergistic effect of diverse and even contradictory philosophical insights into an RIS. In a region-nation synthetic view, innovation needs to fit regional schemes and national agendas according to the observing target; policy stream; the system's scale, range and roles; systemic problem range; innovation goals; system contexts and observers; and internal dynamics and innovation interpretation.

When this dualistic view is combined synthetically with mental models in SD practice and theory in policymaking, the dualism of different philosophical insights considers and mediates different interests generated by different mental models and philosophical views about systemic problems. That is, a dynamic political and social system over time finds it impossible to stick only to one insight into its system, so that the perception of its systemic problems and the corresponding managerial solutions are likely to change over time. Therefore, system dynamicists in the innovation policy area are recommended to maintain a repetitive process of 'thesis-antithesis-synthesis', in view of the ever-changing conditions within and around an innovation system.

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