

On the Dynamics of Network Synergy

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1. Space-Time Aspects of Innovation Diffusion

Space-time geography has already a long history, starting from the path breaking work of Hägerstrand (1967). The formal structure of this approach was largely based on statistical simulation experiments. Only in more recent years rigorous modelling experiments have been designed to encapsulate the complex synergetic patterns of interacting phenomena in space and time. Consequently, in recent years concepts like 'complex spatial dynamics' or 'spatial evolution' have gained increasing popularity in the regional science and geography literature. The space-time mapping and analysis of phenomena with unexpected or unpredictable dynamics has next also become a focal point of research. Much attention has been given in the past decade to the question whether complicated—often multi-layer—processes of spatial development can be represented by (seemingly) simple equations of motion that are able to capture a variety of space-time processes. The main intention is of course to increase our level of understanding regarding phenomena whose evolution cannot adequately be depicted by conventional growth models. The present paper aims to make a further contribution to this field by developing a synergetic space-time model for the logistic evolution of a spatial system. Without loss of generality, we will develop this model—for the sake of real world interpretation—for the case of technological innovation and related space-time diffusion and adoption behaviour.

Techno-economic evolution and spatial dynamics are often two intertwined and parallel phenomena. Space does not only act as a geographical dimension upon which techno-economic changes are projected, but it also serves as a medium of opportunities and barriers through which such techno-economic changes are transmitted or filtered. In this context, Stoneman (1983) has made a useful distinction into the generation of new technology, the diffusion pattern of new technology (including the adoption of innovations), and the socio-economic impacts of these processes. In recent studies much attention has been devoted to the analysis of conditions (so-called critical success factors) that are favourable to innovation processes and their diffusion: knowledge intensity of firms, communication networks, market forms, capital intensity, accessibility to suppliers and markets, organisational and logistic structures, and so forth (see Bertuglia et al., 1997; Van Geenhuizen, 1993, and Kamann and Nijkamp, 1990). It is now widely accepted that techno-economic innovations and their adoption do not take place as 'manna from heaven', but are the result of creative, adoptive and adaptive strategies of economic actors (see Kleinknecht, 1987).

The conditions for generating new and economically successful technologies (the so-called 'technogenesis') and the adoption and adaption conditions for such innovations are unequally dispersed in space and occur often in clusters. Patterns of innovations exhibit a clear spatio-temporal trajectory as a result of product life cycle patterns and distance friction elements (see Davelaar, 1990). Such different patterns are not only caused by differences in sectoral composition or strategic behaviour of firms in different areas, but also by differences in spatial policy and individual and group life styles. Thus the socio-cultural component—influenced by history and geography—tends to influence the behaviour of adopters and adapters of actors and groups. The

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behavioral strategies of such actors and groups in regard to new techno-economic innovations (e.g. telematics, mobile telephone etc.) are hence also related to the availability of communication tools and technologies acting as new space-opening opportunities (e.g., the French Minitel) or space-reducing barriers (e.g., high telecommunication costs). This means that the performance of actors (individuals, groups, cities) is largely determined by their strategic position in a spatial contact network (see Nijkamp and Reggiani, 1992a). However, modelling such space-time phenomena is fraught with many difficulties (cf. Blommestein and Nijkamp, 1987).

In the context of space-time diffusion it should be noticed that nodes in a network will normally play a crucial role. Especially cities often act as the cradle of many new ideas (by either generating them or adopting them quickly), so that cities fulfil an important seedbed or incubation function. However, in exploring and explaining the innovative 'milieu' of cities (often called the 'urban selection environment'), the dynamics of the processes involved is not always well understood. Most research in the techno-economic innovation field has been dominated by (comparative) static analyses.

Against this background, the present paper aims to construct a dynamic, spatially competitive model of actors (e.g., nodes in a network) who aim to improve their relative performance (or utility) by a creative generation, adoption or adaption with respect to new techno-economic opportunities. Particular attention will be paid to evolutionary space-time processes of innovation diffusion, with particular emphasis on the implications for spatial interaction (e.g., in transport and communication systems). By way of introduction, Section 2 will be devoted to a concise overview of spatio-temporal diffusion patterns of innovations, with particular attention to nonlinear models from the viewpoint of their capability of capturing structural changes in evolutionary processes with the possibility of complexity, specialisation or cooperation among different actors (see Nijkamp and Reggiani, 1993a). In subsequent sections, we will then offer new dynamic approaches to the spatial dynamics of innovation diffusion.

2. Modelling Innovation Diffusion in a Space-Time Context

Innovation research dates already back to the first part of the twentieth century. An innovation is according to Schumpeter (1934) a new product, a new production technology, a new material or a new organizational structure. Research on innovations has traditionally chosen two distinct directions: (1) the **user's side** (innovations adopted by households), and (2) the **supply side** (innovations created and adopted by firms). In both contexts, attention has recently been paid to space-time patterns of diffusion.

The first empirical studies dealing with models of social diffusion processes are related to such different topics as the diffusion of the prescription of a new drug (Coleman et al., 1957), the implementation of mandatory schooling by different states in the U.S. (Pemberton, 1957), the diffusion of hybrid corn among farmers (Griliches, 1957) and even the process of entry into first marriage (Hernes, 1972) (see for a review Diekmann, 1992 and Hamblin et al., 1973). In these studies modelling social diffusion processes is combined with estimation techniques for survival analysis and thus with the log-logistic distribution which is frequently applied in survival analysis (see again Diekmann, 1992).

From the viewpoint of the **time dimension**, a common approach in diffusion research is the **epidemic model** approach (see, for a review, Brown, 1981, Fischer, 1989 and Rogers, 1993) leading to the well-known sigmoid path of the development of the adopter's diffusion trajectory, usually represented by a logistic curve. The logistic function appears to be, in general, well suitable for representing different speeds of diffusion and also irregularities according to different forms of S-shaped time distribution functions (steep, flat, delayed). Figure 1 shows the logistic form of three different innovations which vary in their relative rate of adoption. In particular we may refer here to the following quotation: "Innovations that diffuse more rapidly are generally characterised by

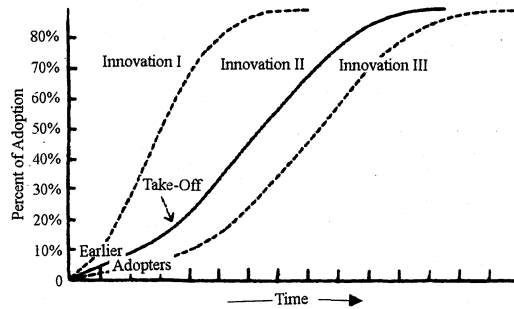


Figure 1. Some Adoption Curves (Source : Rogers 1993, p. 16)

greater relative advantage, more compatibility, less complexity, more triability, and greater observability" (Rogers, 1993, p. 16).

In the innovation diffusion literature many models based on an S-shaped form have been proposed (for example, the models developed by Fisher-Pry, 1971 and by Bass, 1969 with a symmetric S-shape, or the models developed by Eansingwood et al., 1981 and Floyd, 1968 with a non-symmetric S-shape). A review of most of these models can be found in Mahajan et al. (1990) and more recently in Kapur et al. (1992). Also the study of the turning point—or point of inflection—has received a great deal of attention, from both the user's and producer's side (see e.g., Kumar et al., 1990). However, many of these models seem to work only under specific conditions due to their intrinsic restrictions on the shape of diffusion patterns. Additionally, a drawback of the logistic model is the assumption of a 100 per cent saturation at the final stage of a diffusion process, a situation which is seldom reached in reality. Therefore, the reliability of this model may be low at levels close to saturation (see EURONETT, 1990).

From a methodological viewpoint, the logistic approach has interesting features because of its roots in **bio-ecological** modelling and hence in the so-called '**biophysical**' approach which regards each technology and product as a species engaged in some sort of population dynamics, with synergetic and/or competitive effects (see, e.g., Marchetti and Nakicenovic, 1979, and Silverberg, 1992). The significance of the formal-interpretative strength of the logistic function has been emphasized by Nijkamp and Reggiani (1992a, 1993b) in their analysis of the relationships between **competition and stability** in a spatial dynamic system. A step further in this approach is its orientation towards **niche theory**—embedding the logistic function—for analyzing the evolution of a self-organizing system, in which the entry of new competitive goods generates new dynamics (see Nijkamp and Reggiani, 1992b). This has been elaborated for a transportation system, in which a complex multi-layer structure—where each subsystem (modelled by a niche envelope) interacts with one another at different levels/capacities of the system—can be identified and analyzed (see Reggiani and Nijkamp, 1994). In this approach—where the capacities of the system are considered as time-dependent and embracing a chain of subniches—also the interdependence between economic and ecological theories of evolution is pointed out on the basis of an analogy to Rosser's analysis (1991). In this framework, both **continuous** and **discontinuous** (even **chaotic**) **processes** may occur, thus linking Schumpeter's (1934) theory on technological change (as a discontinuous process) to the neoclassical theory advocated by Marshall (1920) (on continuous and gradual evolution of the market/technology structure) (see also EURONETT, 1990).

It is noteworthy that these competition/niche models—usually represented by interrelated logistics like the Lotka-Volterra type of equations—are related to the family of Turing's models of biological morphogenesis, in which two cells interact via diffusion through a thin membrane. According to Smale (1974), this model goes beyond biology, as it shows how the linear coupling of

two different kinds of processes—each process in itself being stationary—can produce an oscillation. This is similar to the coupling of transport processes and transformation processes (see Nallari, 1992). An interesting link between Lotka-Volterra models and ‘Schumpeterian’ competition analysis (i.e., the competitive exclusion of non-efficient innovation alternatives) has been provided by Sonis (1992) in the framework of collective dynamic choice behavior, who emphasized the necessity of considering discrete time versions of the innovation diffusion dynamics in applied geographical research.

A third branch of models—pertaining to nonlinear models of technological change/innovation—is the category of **catastrophe models**. Catastrophe models, based on the mathematics of differential topology (see Thom, 1975), depict both continuous and discontinuous change under some maximization or minimization (cost) function (the so-called potentials). Such catastrophe models are well-known and further details can be found in, for example, Stewart (1975) and Woodcock and Davis (1978). For applications of catastrophe models to technological change systems we refer to Andersson et al. (1992), Goodwin (1980), Nallari (1992) and Zhang (1992). A clear drawback of these models is the near-impossibility of calibrating the relevant parameters, since the dynamic equations are usually expressed in continuous time. However, the qualitative solutions, based on an interpretation of the switches from one (economic or technological) regime to another, appear to be a powerful tool for analyzing structure impacts of innovations.

In this stream of research we may also mention **bifurcation models** of catchup dynamics between different regions with significant welfare discrepancies (see, for a review, Silverberg, 1992), as well as growth models for regions or countries with **endogenous technical change and divergence** (see, for a review, Nijkamp and Poot, 1993). Since these two classes of models are essentially Lotka-Volterra or competition models, it is clear that bifurcations, cycles and irregular/chaotic patterns may emerge for particular values of the parameters and initial conditions.

From the perspective of the **spatial dimension**, two geographical regularities of innovation diffusion are usually investigated (see Fischer, 1989). Firstly, the ‘neighborhood effect’ (see, e.g., Hägerstrand, 1967), emphasizing the relationship between distance and the sequence of innovation adoptions (where distance can be measured in physical, socio-cultural or technical-economic terms). Secondly, the ‘**spatial regularity of innovation diffusion**’ (see, e.g., Ewers and Wettmann, 1980), emphasizing the urbansized hierarchy as the prime determinant of the diffusion process.

It should be noticed here that recent research also points at the **fractal** nature of spatial diffusion (see, e.g., Basu and Kabre, 1992) as well as its **cluster** character (see Grübler, 1991), as this process may exhibit regular patterns in the discontinuous processes of the spread of innovations.

However, the **explanations** for the diffusion process of technological innovations are still not satisfactory. Only a few studies have focused upon regional-national differentials in the diffusion process or have attempted to explain the causes of such disparities (see again, Fischer, 1989). In this context, we refer to two recent interesting studies (Nakicenović and Grübler, 1991 and Karmeshu, 1992) where emphasis is placed on the interactional relationships among technological change, socio-cultural history, institutional innovations and economic development. However, a ‘general’ theory is still lacking in this respect, while the main interest has been, on the contrary, in designing specific models for specific problems.

In the light of these recent contributions, the present paper aims to provide a new contribution to the analysis of evolutionary-spatial processes of innovation diffusion by developing a ‘nested’ logistic approach embedding—by means of a dynamic generalized accessibility (or preference drift) function—different socio-cultural behavioural responses or attitudes of adopters in a space-time system. In particular, we will address the question why some innovations have a rapid rate of adoption in a given spatiotemporal and socio-cultural context, while in an other context they are adopted more slowly or not adopted at all. We will first model the dynamics of the socio-attitudinal response related to life style and culture in different regions of a spatial system by

encapsulating in the growth rate a conventional logistic function a dynamic accessibility/cost function of innovative behaviour. Next, we will also investigate the influence of multiple (competing or complementary) nodes in our spatial network, based on either a similar or a different attitudinal response. The investigation of the properties of such a model will be carried out by means of simulation experiments in which different shapes of niche diffusion for different parameter values are assumed.

3. Modelling Diffusion Processes : A Nested Synergetic Approach

3.1 Introduction to dynamic diffusion and synergy

We will start our exploration of nested diffusion models with the following quotation : “Just as biological adaptation is a result of a selection process statistical in nature leading to a change within the virtually same population, innovation acts also within a given commodity population changing some of its ‘average’ features” (Owsinsky, 1992, p. 243). In the past decade, the nature of innovation as an adaptive shift in the dynamics of commodity population following biological laws has been recognized by several authors. It is noteworthy that the methods of evolutionary theory have been successfully applied to innovation processes by several authors, starting from Nelson and Winter (1982) (see, for a review, Ebeling, 1992). A major issue in these evolutionary diffusion models centres round the investigation of the relationship between the growth curve depicting the number of adopters and the channels of communications. So far no clear answer—despite the increasing number of models—has been given to the question of ‘shape’ of an innovation. In other words, **why** has the evolution of innovation taken a specific form or shape for some given geographical contexts/social groups, while—in the same time period—it is shaped in a completely different way for other socio-cultural groups in space. Apparently, the penetration of a technological product in a market does not only depend on the economic conditions of the users (see for example, the high percentage of faxes/mobile telephones in Italian households or the high percentage of telephone-boxes spread all over Italy in comparison to other countries, like the Netherlands, Sweden, England, etc), but—as already noticed in the previous sections—also on the socio-attitudinal features of the relevant groups/regions/countries.

This section will focus on the key elements of the dynamics of diffusion curves by starting from an interpretation of innovation which is usually ignored in the models reviewed so far. In particular, we will consider here **the evolution of an innovation** as an example of ‘**morphogenesis**’ where changes in the parameters affect the form and shape of the system. In other words, we call more attention for the **dynamic role of the parameters** in the models usually adopted for innovation diffusion. We will first model the **dynamic impact** of the growth rate of a new phenomena upon the well-known logistic diffusion curve, by focussing on the **dynamic feature** of the growth rate of diffusion (for example, by considering an evolutionary process with saturation also in relation to the growth rate). Secondly, we will re-interpret the growth rate parameter as a **dynamic accessibility/cost preference function** embedding all those characteristics (cultural, ethnic, demographic, political, social, economic, etc) which make an innovation more desired or accessible for certain groups/regions than for others. The key factors in our model are the **interaction parameters** which may be conceived of as critical forces in a **dynamic synergetic** way and which are nested in the diffusion equations of the populations—in the respective centres/regions/countries—adopting the innovation. In other words, we will consider the parameters of the adoption function as dynamic (following again a logistic/niche function), while we will link the parameters of both these equations in a ‘compound’ multiplicative relationship generating a synergetic effect (synergy refers to the Greek word ‘synergos’, i.e., work together for joint benefits). It is also proper to refer here to the words of Haken, the ‘father of synergetics’: “Synergetics focuses its attention on those situations where these systems change their macroscopic behaviour quantitatively, or in other words, where new qualities of a system emerge. Synergetics can be considered as a strategy of how to cope with

complex systems... The reason for the wide-spread applications of synergetics lies in the fact that it has unearthed general principles which are at work when systems acquire spatial, temporal or functional structures via self-organization. Self-organization means that the formation of these structures is not imposed on the systems from outside but is found to be carried out within the systems themselves" (Haken, 1992, p. 147). In our context, the interaction parameters are the driving forces leading to synergetic/cooperative phenomena.

3.2 The model used

In this subsection we will first model the (relative) evolution of the adoption of a certain innovation, based on the assumption that the adoption process is governed by the well-known logistic curve. It is interesting to know that this curve is able to capture—despite its simplicity—both growth and decay of an evolutionary process. We assume here a set of logistic equations for each specific group or region i :

$$x_{i,t+1} = x_{i,t} (K_i - a_{i,t} x_{i,t} + \sum_j c_{ij} x_{j,t}) \quad (1)$$

where $x_{i,t}$ represents the number (or share) of people (or actors) adopting a given innovation in a certain group/region i ($i, j = 1, \dots, N$) at time t ; K_i is a parameter proportional to the saturation level of the population of adopters in group or region i ; $a_{i,t}$ is a (dynamic) growth parameter; and c_{ij} is an interaction (synergetic) coefficient between i and j .

Equation (1) is a generalized version of the conventional substitution model of innovation diffusion, since the growth rate $a_{i,t}$ is considered here to **vary over time**, following the argumentation given in Subsection 3.1. In this model, we will interpret the growth parameter $a_{i,t}$ as a special type of dynamic acceptance (or accessibility) function measuring the preference intensity of the population in a group or area i , which generates an attitudinal response of population x_i . Thus this parameter, which may inter alia depend on (generalized) price functions of the innovations, expresses the 'ease' of penetration of an innovation in the market i .

So far we have not discussed the shape of the time-dependent parameter $a_{i,t}$. It seems plausible that this new dynamic preference drift variable follows again a logistic evolution with a rapid/slow growth rate depending on the social context at hand:

$$a_{i,t+1} = a_i (A_i - b_i a_{i,t} + \sum_j f_{ij} a_{j,t}), \quad (2)$$

where A_i is again proportional to the saturation level of the preference intensity (carrying capacity) of system i ; b_i is the receptivity or intrinsic 'ease' of adopting innovation i (which is independent of the communication/interaction effect), while f_{ij} is the interaction parameter.

Furthermore, we also assume in equation (1) the existence of a synergetic effect on the adoption rate and the preference drift in connection with an attitudinal response for the innovation concerned. This implies in the first place that the speed of penetration is also determined by the adoption rates on other (competing) markets. This is reflected by the final term in brackets in equation (1) where c_{ij} reflects the synergetic effect. Next, we assume that in equation (2) the interaction parameters f_{ij} are also influenced by c_{ij} , so that as a result of these synergetic effects on other markets j (denoted by the parameter c_{ij}) the parameters f_{ij} can be specified by assuming the following compound relationship:

$$f_{ij} = e_{ij} \cdot \sum_j c_{ij} \quad (3)$$

where e_{ij} represents the 'pure' interaction effects in the preference function (2) in the absence of interaction effects among the adopters in the respective groups or regions. It is noteworthy that a **multiplicative synergetic function** as adopted in (3) is a frequently occurring specification in the network literature, as it reflects essentially the existence of 'club externalities' in a social interaction

context (see also Capello, 1993). Thus, given the nested link between the dynamic equations (1)–(3), and the inclusion of the carrying capacity A_i in (2) and of the growth rate b_i (which is assumed to reflect the intensity of attitudinal response of population i to a particular innovation), we may next identify the impact of different shapes of the (niche) diffusion of an innovation on population i .

It is noteworthy that the above methodology is closely linked to the so-called ‘**expansion method**’, as is illustrated by the following quotation: “For instance, it would not be unreasonable to postulate that the relation between population and product per capita drifts over time, which would lead to expanding the c parameters; or that the elasticity parameters in the production function drift over time, which would suggest expanding them. The expansion methodology carries within itself the open-ended suggestion to select simple initial formulations, to model by expansion equations the variation of their parameters across relevant contexts, and then to test for the empirical occurrence of such variation” (Casetti, 1989, p. 1478). A review on samples of the expansion method can be found in Casetti (1986) and Casetti and Jones (1992). While an analytical exposition of the parameter mapping approach is given in Bennett (1979). Further examples can be found in Kristiansen (1995). In this context, it should be noted that the novelty of our approach lies in the nested design of a non-linear expansion method of the logistic type in contrast to the common linear equation system or non-linear equation system without a saturation term.

Although, the model developed here is simple in structure and conception, it may be able to mirror a wide spectrum of different space-time evolutions of a dynamic system adopting innovations. This will be further investigated by means of simulation experiments in the next section.

4. Simulation Experiments for a Synergetic Dynamic Model for Innovation Diffusion

It is evident that the above models are difficult to test in reality, as long spatio-temporal time series on innovation diffusion are hardly available. Nevertheless, since our synergetic space-time model is based on reasonable hypotheses, its degree of plausibility may be investigated by analyzing the behaviour of the model by means of simulation experiments. Furthermore, relevant typologies on the behavioural features of the adopters (e.g., stable, unstable etc.) can be made on the basis of such simulations.

In the first step of our analysis we will examine the properties of our model for two spatially different cases (a) and (b), both concerned with areas (or centres) connected by means of a spatial network characterized by actor dependency. Case (a) will deal with two interacting regions with significantly different attitudinal responses to innovation, whereas Case (b) deals with three regions (for example, a centre and a periphery in one country interacting with a centre and a periphery in another country). These cases will now successfully be discussed and illustrated by means of simulation experiments.

4.1 The case of two areas (core/periphery)

Let us first assume the case of two areas, viz. a metropolitan core and a peripheral area in the same region or country. Now it seems plausible to assume a high preference intensity—leading to a relatively higher attitudinal response to innovation—for adopters/users in the metropolitan region (with population x_1) compared to adopters in the peripheral region (with population x_2). The models (1) and (2) applied to this case are then the following:

$$\begin{aligned}
 x_{1,t+1} &= x_{1,t}(K_1 - a_{1,t} x_{1,t} + c_{12} x_{2,t}) \\
 x_{2,t+1} &= x_{2,t}(K_2 - a_{2,t} x_{2,t} + c_{21} x_{1,t}) \\
 a_{1,t+1} &= a_{1,t}(A_1 - b_1 a_{1,t} + f_{12} a_{2,t}) \\
 a_{2,t+1} &= a_{2,t}(A_2 - b_2 a_{2,t} + f_{21} a_{1,t})
 \end{aligned} \tag{4}$$

where the parameters f_{12} and f_{21} have a multiplicative form, as described in (3), and depend thus on e_{12} , c_{12} and e_{21} and c_{21} , respectively. We will also assume in the core area higher values for the

saturation levels ('ceilings') of both attitudinal responses and the population of adopters, as well as for the intrinsic growth rate of the preference drift function, so that :

$$\begin{aligned} K_1 &\geq K_2 \\ A_1 &\geq A_2 \\ b_1 &\geq b_2 \end{aligned} \tag{5}$$

Model (4) is, therefore, a **nested network** model, since the **growth rate of the adopters** is assumed to be **dynamic** and thus embedded in the 'attitudinal' function of the adopters themselves. It should be noted that if we consider the interaction effects of the periphery in a competitive way rather than a synergetic way, we will end up with a **two-layer niche substitution model**. The solution of system (4) cannot be written in a closed form and is thus inconvenient for any numerical work. Thus we will carry out a sensitivity analysis based on simulation experiments. In particular, we will investigate the impact of the 'attitudinal' functions $a_{1,t}$, $a_{2,t}$ on the population of adopters x_1 , x_2 , by varying the related growth rates as well as the carrying capacities of the system. In principle, it can be shown that, by increasing the above parameter values, the respective systems give rise to unstable phenomena. Several simulations can now be carried out to trace stable or unstable behaviour.

5. Conclusions and Future Research Directions

Evolutionary dynamics appears to offer a new paradigm for investigating stability of dynamic non-linear systems. This also applies to sociotechnical systems such as transportation and communication technologies or general innovative technologies. In this context the dynamic logistic growth function—extended and generalized in a nested niche framework—appears to offer a great potential for investigating dynamic attitudinal responses.

It is noteworthy that the attitudinal function adopted in our approach appears to be able to exhibit both regular and irregular logistic shapes, whereas the diffusion trajectory of new technologies in a spatial setting always displays a niche shape with a decay function moving toward a zero level after some time periods.

These findings also provoke new research endeavours, notably in the area of calibrating the underlying dynamic structural model with particular attitudinal attention to the preference/attitudinal function (for instance, by looking into the potential of telematics in transport systems). In this context socio-psychological and micro-economic research into the extent and influence of geographical space in the attitudinal responses would be needed.

A further natural extension would be towards a full integrated network configuration with multiple nodes and links. The ensuing complexity issues may then probably fruitfully be investigated by means of neural network approaches.

Next from an economic behavioral viewpoint the role of the price and cost indicators needs more investigation, with a particular view on transaction costs and risks attitudes in adopting new technologies in a competitive environment.

Finally, the question of the empirical validity of the above approach deserves some more attention. In the absence of data on evolutionary phenomena like space-time innovation diffusion, a blend of plausibility reasoning based on partial theoretical analysis and simulation experiments seems to be a viable way. In this way various evolutionary trajectories can be traced and confronted with limited empirical data. Furthermore, the parameter values assumed in the simulation models can partly be checked against known values from other studies. Clearly, this does not offer a solid verification, but the main aim of the present paper was less ambitious: it aimed to show the relevance and potential of space-time synergetics analysis for innovation diffusion, with particular attention for the role of socio-attitudinal response changes in the population of adopters interacting in a geographical context of interdependent spatial behaviour. It goes without saying

that a major item on a future research agenda has to be the empirical testing of the above evolutionary pattern in case of spatial synergy.

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