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Nikias Sarafoglou
Jean H.P. Paelinck

On Diffusion of Ideas in the Academic World: The Case of Spatial Econometrics

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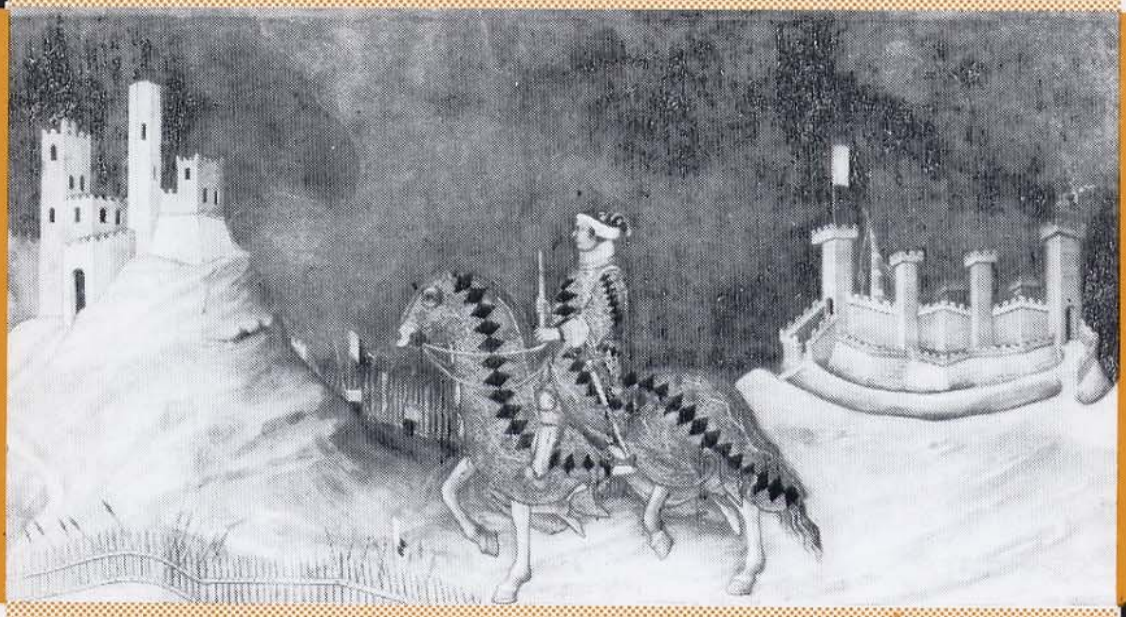

Abstract - Spatial econometrics is a fast-growing field in the series of quantitative disciplines, auxiliaries of economics and related social sciences. Space, friction, interdependence, spatio-temporal components, externalities and many other aspects interact and should be treated adequately in this field. The publication of the Paelinck and Klaassen book in the late 1970s generated virtually the field spatial econometrics

This article studies the diffusion of spatial econometrics, through experienced history on the one hand, on the other through bibliometric methods. Although this field was an "Invisible College" up to 2006 (absence of any organization in form of association, conference, journal, etc.), the databases depict a fast diffusion in the past and strong prospects for the future.

JEL classification: B2, B4, C4, C5, R1.

Nikias Sarafoglou, George Mason University, School of Public Policy, e-mail: nsarafog@gmu.edu
Jean H.P. Paelinck, George Mason University, School of Public Policy.

1. Introduction.

The quantitative diffusion of industrial innovations has been studied extensively in the last fifty years (see Griliches, 1957, Hagerstrand, 1967, Haynes et al., 1977, Geroski, 2000, Mansfield, 2002, Rogers, 2003). Many scientists have advocated that the diffusion of innovations is of great importance, because innovations generate productivity increases of production processes. On the contrary, the diffusion of ideas in Academia is a subject with very limited references (Reisman, 1992; Forsund and Sarafoglou, 2002 and 2005; Gattoufi et al., 2004; Heap and Parikh, 2005). The diffusion of ideas is of great importance too for the academia and for the economic system.

Two instrumental variables have been used for the measurement of the diffusion of ideas:

a) the number of articles using the particular idea as a keyword;

b) the number of citations of the most important articles generating the particular idea.

To set the following citation analysis in the right perspective, it is important to recognize that about 66% of journal papers, in general, receive no citations except self-citations. Social Sciences citation levels have been found to peak at between 5-7 years after publication, with a long tail stretching beyond the 7^{th} year (see e.g. Price, 1976, and Johnson, 1977, for studies of diffusion distribution).

There is the well known metaphor of Academia referring to "the market place of ideas" which implies that the diffusion of ideas throughout Academia will be quick and effective. Heap and Parikh (2005), deal with the diffusion of "Econometrics" and "Experimental Methods in Economics"and demonstrate that the metaphor was a good fit for the diffusion of Econometrics, but not for the diffusion of Experimental Methodology in Economics.

Most of these studies of the diffusion of ideas are based on epidemiological models of contagious diseases. Following Bettencourt et al. (2006), the epidemiological models take on one of four states at any time in the process of diffusion:

S=susceptible; I=incubators; A = adopters ; N= non users (recovered);

if we accept the hypothesis that the spread of epidemics and idea diffusion are similar processes, the most probable population dynamics of diffusion can be depicted as:

$$S \rightarrow I \rightarrow A$$
$$S \rightarrow I \rightarrow A \rightarrow N$$
$$S \rightarrow I \rightarrow N$$
$$S \rightarrow N$$

The individuals can exit these states at any time.

The statement of Hodgson and Rothman's (1999) article on "Editorial oligopolistic markets in Economics" has important implications for the diffusion of new ideas in that they found that the oligopolists do not tend to accept or adopt new ideas, and thus for them the diffusion of ideas will be slower. In short, in an oligopolistic dominated market idea diffusion and adoption will, ceteris paribus, be slow. Keynes, when serving as an editor of the *Economic Journal* in the 1930's, generated a slow diffusion of Econometrics. He considered indeed Econometrics as "a historical curve fitting", with a minor importance for the development of Economic Theory. (There are articles and letters between Keynes, Frisch and the "alchemist" Tinbergen, which document Keynes' behaviour)[1].

Mirowski (1999) studied the diffusion of Operations Research in terms of citations. He found out that the heterogeneity of Operations Research scientists was very important for the citations dynamics of the field: "When outsiders (engineers, physicists, computer scientists) "invade " a field, it is often the case that "trespassers" (are) oblivious of their predecessors" .

The number of citations does not necessarily measure the "true" value of journal contributions, but papers achieving classical status (at least 500 citations) should have a high probability of presenting advanced new paradigms, or new methods. With papers of such high impact there is the danger however that their advancement of knowledge has become intrinsic. This is referred to as "obliteration by incorporation" in Zuckerman (1987): the key concepts are used without reference, becoming canonical knowledge or household expressions, like Central Place Theory in geography or the Cobb-Douglas function in economics.

However, some caution concerning the use of citation indices is well justified. As Garfield says " It is prosperous to conclude blindly that the most quoted author deserves the Nobel prize. On this basis, Lysenko and others might have been judged the greatest scientists of the last decade". In other words, there is no discrimination between favourable and unfavourable citations (see Sarafoglou and Haynes, 1990 and 1996).

The diffusion process can be idiosyncratic as in the case of "Rational Expectations" (RE). Muth initiated the theory of RE in the beginning of 1960's, but Lucas activated RE-research in the mid 1970's. As Thomas Sargent (1987) wrote:
"….it was not until the writing of Lucas' Critique in 1973 and its publication in 1976, that the implications for econometric practice of Muth's ideas …began to be widely accepted.".

This article studies the diffusion of spatial econometrics, through experienced history on the one hand, on the other through bibliometric methods. Although this field was an "Invisible College" up to 2006 (absence of any organization in form of association, conference, journal, etc.), the databases depict a fast diffusion in the past and strong prospects for the future.

In what follows, spatial econometrics ("SE") is considered, first in a historical setting, then analytically using quantitative data.

Conclusions and references follow as usual.

2. History of spatial econometrics.

Spatial econometrics has been a fast-growing field in the quantitative disciplines that are auxiliaries of economics, geography, regional science and related social sciences, and is now becoming mainstream in economics, geography, regional science .

The subject matter is all the more complex as it has a twin brother, spatial statistics, which in many aspects is complementary to SE.

We essentially describe the evolution of spatial econometrics as recently experienced, and presently practiced, referring to other materials to cover spatial statistics proper; a recent paper with references to this interface between spatial statistics and spatial econometrics is Griffith and Paelinck, 2007.

The next sub-part of the paper is devoted to an obscure period of the discipline, when essentially "spatial econometrics without space" was practiced; then, progressively, the spatial component emerged more formally, and fragments of real spatialized exercises could be excavated from dispersed articles and books, as part three explains.

In 1979, a number of principles were defined that - so it was hoped - would guide future work along lines that tried to identify the specificity of spatial econometrics, totally respecting the teachings of general econometrics; the same applies to theoretical spatial economics, which integrates all the principles of general theoretical economics.

2.1. Dark ages.

Econometric artcles published over the 50's and 60's were of the most classic linear statistical type, relating only variables possessing the same regional index. Examples are Thompson and Mattila, 1959 (see the comments on this study in Paelinck and Klaassen, 1979, p.6), and Vanhove, 1963; the latter being used in an methodology to calculate the parameters of an optimal multiregional policy (Paelinck, 1967). However even then it was noted that the underlying model was inadequate to represent the correct spatial workings of the economy. To quote from Paelinck, 1967, pp.57-58:

> "…....les résultats de l'économétrie régionale, telle qu'elle est souvent pratiquée, sont fortement affectés par la négligence de deux facteurs essentiels:
>
> - la localisation relative des régions faisant l'objet de l'étude;
> - la localisation intra-régionale des activités sur lesquelles porte l'analyse.
>
> …De statique et indifférenciée, l'économétrie doit devenir *dynamique et différenciée*; des modèles adaptés au *caractère spécifique de l'analyse régionale* doivent être mis au point."

In summary, regional econometrics as practiced in the past, neglected two essential factors: relative location of the regions concerned, and the intraregional location of activities.

The same criticism, levied against regional macro-models, was repeated in Paelinck, 1973.

One can ask the why no attention was being given to spatially entwined activities? On the one hand, time series analysis recognizes the importance of serial correlation, though it was reflected particularly in terms of stochastic terms or residuals. On the other hand, input-output analysis was starting to develop multi-regional variants, though typical topological variables were absent. Furthermore, in studies of inter-regional and international movements (inter-regional migration or inter-zonal commuting, international trade) gravity models were in use, which implied the use of certain distance decay measures.

The meaning of these early efforts lies in the fact that the bridge between spatial analysis and econometrics proper had still to be built. The progress in building this bridge is discussed in the next section.

2.2. Archaeology.

Things changed significantly in the late sixties and seventies.

In 1966 (see also Lebart, 1969), a colleague of the second author at the "Institut d'Etude du Développement Economique et Social" of Paris University, Ludovic Lebart, applied the Geary statistic (Geary, 1954) to French departmental data, generalizing it and studying spatial autocorrelation at different degrees of contiguity, hence measuring distance effects, as a contiguity metric.

A similar study was published in Paelinck and Nijkamp (1975, pp.223-234 and 243-246) using five different variables (number of inhabitants per square kilometer, rate of growth of population, employment per square kilometer, per capita gross value added at factor prices, per capita available income); the first variable showed systematic positive spatial autocorrelation, the second and third ones a negative one, the last two variables again positive autocorrelation (except at order two). These findings, for 1960 and 1965, gave an acceptable insight into the spatial structure of the variables taken up in the study and provided new insight into the use, value and interpretation generated by the impact of spatial autocorrelation considerations .

Moran's I (Moran, 1948, 1950) gained popularity over the same period with the Cliff and Ord volume (1973) on spatial autocorrelation completing the picture.

However, what was missing was a complete integration of theoretical spatial economics and econometrics. This was what the vision of a "Spatial Econometrics" (1979) was meant to address.

2.3. Modern era.

The initial vision on what spatial econometrics could be was expressed in the second author's General Address to the Dutch Statistical Association, on the occasion of its Annual Meeting on May 2nd 1974, in Tilburg.

The integration process was laid down in the form of five principles:

The first one was already introduced by the previous considerations, to spatial interdependence. The new vision was to derive that interdependence from the workings of spatial economies. Two models were essentially outlined, an income generating model and a so-called attraction model. The first started from a spatial generalization of the Keynesian macro-economic consumption-cum-investment model, introducing spatial shopping behavior and generating spatial consumption propensities. The second was a generalized Weberian sectoral location model, based on locational choices as a function of expected profits. Without going into detail, it should be noted that the classical econometric problems of specification, dimensional homogeneity, identification, estimation, testing were systematically addressed.

The second principle was that of spatial asymmetry in the measures of spatial interdependence.

Both of these principles lie in stark contrast to the simple measurement of spatial moving average or spatial autocorrelation error parameters alone.

Principle three was called "allotopy", from the Greek words αλλος and τοπος, meaning respectively "other" and "site"; it alludes to the influence at a distance of exogenous variables, the Weberian location model, already mentioned, being a perfect example of this.

Choice problems in space often lead to non-linear solutions, so this too should be reflected in the model specification, especially if the model intends to picture ex-ante choices. This was the case of locational models (see e.g. the European FLEUR-model: Ancot and Paelinck, 1983), though their resulting ex-post behavior (for instance, transport flows) could still be treated linearly.

Finally, topological variables (locations, distances, densities,…) should not be absent. Earlier, spatial models were not "without space" however it was handled explicitly. The choice of a distance measure is a strategic moment in model specification, and often too little attention is given to the problems of the metric topology involved.

As spatial econometrics *is* about economics, much stress was laid on the specification of the underlying model, or, in other words, the first moments of the distributions, so to say (see Paelinck and Klaassen, 1979, conclusions to chapter 2, pp.42-43).

A stormy evolution took place, in volumes devoted to spatial econometrics. Skipping but not neglecting these articles, and insisting also on the value of the contributions of a complementary field of spatial statistics (for references, see again Griffith and Paelinck, 2007); one is referred to Anselin (1988), Anselin and Florax (1995), Morena Serrano and Vayá Valcarce (2000), Journal of Geographical Systems (2003, Vol. 5, No 3), Anselin, Florax and Rey (2004), Getis, Mur and Zoller (2004), Lesage, Page and Tiefelsdorf (2004), Trivez et al. (2005), and Arbia (2006).

2.4. Platforms.

As can already be seen from the references just mentioned, the main publication platforms are journals within the realm of regional science; no specific SE journal is was available.

The same applies to congresses, those of the Regional Science Association International, the North American Regional Science Association, the Western Regional Science Association (the Getis et al. 2004 volume stems from one of them), the Association de Science Régionale de Langue Française, to mention any a few were the only opening for such research. Special issues of *Regional Science and Urban Economics* (1992) and of the *International Regional Science Review* (1997) should also be cited in this context.

Specific workshops were initiated, including University of Zaragoza (Spain), Faculty of Economics (2004 and 2006, a two-yearly workshop in honor of the second author), Kiel (Weltwirtschaftliches Institut, 2005) and WRSA.

The foundation of the Spatial Econometric Association (SEA), at Rome, on May 26th 2006, on the occasion of another international workshop on spatial econometrics. Article 2 of its statutes stipulated that:

> "The purpose of the Association is to promote the development of the theoretical instruments and practical applications of spatial econometrics - including spatial statistics and spatial data analysis.
> Spatial econometrics should be regarded in abroad sense and inclusive of the developments of statistic models and instruments to analyse externalities, interactions etc. in different areas such as, without limitation, economics, geography and regional sciences. The mission of the Association is to disseminate and encourage knowledge and good practice among universities and research institutions and in the community in general, becoming a reference point for operators in the field."

The activity of SEA is still too recent for further comment, but a specific SE platform is now present from which diffusion can proceed. Hence the time has come to study the quantitative dynamics of the underlying diffusion processes.

3. Bibliometric analysis.

In order to study the diffusion of SE, the citations of two books on the one hand, and SE related dissertations on the other, will be used.

The two books are:

a) Paelinck and Klaassen, 1979; the authors of this book initiated the sub-field SE;

b) Anselin,1988; this is the most influential book in the short history of SE

The chronological publication distance of these books is not so important per se for the diffusion of SE. But two communication and retrieval “revolutions” took place during this period 1979-1988 and included a) The introduction of the e-mail system in the mid 1980s catalysed the communication of SE-researchers, especially the communication of the Europeans researchers with their American and Japanese colleagues b) The introduction of the new retrieval system of the bibliographic information in the mid 1989:s. The use of CD-

ROM as a storage unit of the bibliographic databases increased the access of SE-references, and the bibliometric evaluation of the literature started. Table 1 presents the first basic data.

Table 1: Diffusion of Paelinck-Klaassen *-1979-citations by journal and by region during the first decade by using ISI's bibliometric databases SCI and SSCI*

Index	**Year**	**Journal**				**Region First Author**		
		Regional Science	Geo--graphy	Eco-nomics	Other	Europe	Americas	Other
1	1980	X				Cardiff		
2	1981	X				Leiden		
3	"		x				Everett, WA	
4	1982	X				Berlin		
5	1983		x			Rotterdam		
6	"		x					Hong Kong
7	1984		x			Kent		
8	"			x		Brussels		
9	"	X					Columbus, Ohio	
10	"			x		Paris		
11	"		x			London		
12	1985			x		Cambridge		
13	"		x			Cambridge		
14	1986			x		Rotterdam		
15	1987		x			Sheffield		
16	"	X				Sheffield		
17	1988			x			Santa Barbara	
18	"	X					Santa Barbara	
19	"	X					Santa Barbara	
20	1989		x*				Syracuse	
Sum		7	8	4	1	13	6	1

* The journal is *Economic Geography*, which can be classified both as a geography and an economics journal.

The conclusions from Table 1 are as follows.

1. For the diffusion of SE in its first decade, the RS-journals and Geography-journals were more important than economics journals and other social science journals. *Environment and Planning* was the journal that most frequently cited this work in the early years of SE.

Although the background of authors was in economics and econometrics, the regional science journals and geography journals were more open to accepting SE articles or SE-related articles.

2. The European authors cited for the Paelinck-Klaassen book more than did the American authors during the early period of SE. England was the citation-dominant country in Europe, and the West Coast was the most active reference region in the US.

Table 2 can be viewed as an extension of Table 1. Table 2 continues Table 1 historically by adding the next decade. The citation diffusion of Anselin's book over the decade 1988-1998 was more interdisciplinary than the citation diffusion of the Paelinck-Klaassen book over the decade 1979-1988 The citations in Regional Science-Geography-Economics-journals are still dominant, but citations in Sociology, Political Sciences, Humanities and Computers are more frequent.

Citations in economics depict economists as slow adopters of SE.

The peak-citation year for Anselin's book is 1992. A plausible explanation of the increased diffusion of SE in terms of Anselin's book citations was the development of SE-software options for public use by Anselin and others (see Anselin and Hudak, 1992).

Table 2: Citations of Anselin's book during the period 1988-1998

Index	Year	Regional Science	Geography	Economics	Sociology	Other	Sum
1	1988	1		2			3
2	1989			1			1
3	1990	5	6		1	1	13
4	1991	2	5	2	1	1	11
5	1992	11	4	2	1	7	25
6	1993	1	5	3	1	4	14
7	1994	2	3	4	1	3	13
8	1995	4	5	1	2	3	15
9	1996	5	4	2	2	2	15
10	1997	10	2	10	1	5	28
11	1998	8	7	11	1	6	33
Sum		49	41	38	11	32	171

From the journal papers, what can be said of the future of SE? It is difficult to answer this question, but let us consider the citations of the articles that cited Anselin's 1988-book i.e. the citations of citations index (CC-index). This CC-index is a "probabilistic momentum" of citations. Most of the bibliometric indices are probabilities e.g. Impact Factor.
Higher CC-index of an item means a higher citations-probability for this item in the future.
Anselin's book has a high CC-index, which predicts that Anselin´s book will be cited more in the future.

Table 3: The Citation of Citation Index of Anselin's book:

Paper	Citations	Publication Year	Regional Sciences	Geography	Economics	Sociology	Other
1	242	1995		X			
2	176	1992		X			
3	98	1998	X				
4	97	97			X		
5	87	96	X				
6	80	96	X				
7	79	91			X		
8	79	88	X				
9	75	94					X
10	70	91	X				
11	61	97			X		
12	60	92				X	
13	58	91				X	
14	49	92	X				
15	48	98	X				
16	48	93					X
17	45	92	X				
18	44	93				X	
19	38	92					X
20	34	97		X			

The distribution and the quantity of citations may depict the dynamics of SE: more citations of the key SE publications may mean more adopters of SE in the future!
The subject-diversity of the CC-index might predict that the number of adopters from other subjects, e.g. sociology will increase.

Still another source of information is presented in Table 4.

Table 4: Dissertations with Spatial Econometrics as key word during the period 1980-2005

University	Year	
Cornell	1980	
Pennsylvania	1986	
Oregon State	1986	
Strathclyde-UK	1987	
Ohio State	1989	
Northwestern	1991	
California-San Diego	1994	
Washington	1994	
Wisconsin-Mil	1995	
Harvard	1995	
West Virg	1997	
Cornell	1997	
Wisconsin-Madison	1998	
Maryland	1998	
California, Berkeley	1998	
Yale	1999	
G. Washington	2000	
KTH-Sweden	2000	
Florida	2000	
New York-Albany	2001	
Cornell	2001	
Cornell	2001	
California-Davis	2001	
Texas-Dalas	2001	
Cornell	2002	
Chicago	2002	
Michigan	2002	
West Wirgiania	2002	
Georgia State	2002	
Maryland Col- Park	2003	
Illiniois-Urbana	2003	
Maryland Col- Park	2003	
Clemson	2003	
California-River.	2004	
Mishigan	2004	
Colorado State	2004	
Rutgers-NB	2004	
Rutgers-NB	2004	
Texas A & M	2004	
Boston Col	2005	
Pennsylvania	2005	
Ohio State	2005	
Texas-El Paso	2005	
Maryland Col-Park	2005	

Source: Dissertation Abstracts

This dissertation database includes mostly dissertations from North America; there are some dissertations from Europe, but the European data are not so as reliable as the U.S data in this database (at Erasmus University Rotterdam 3 SE dissertations were defended, in 1983, 1986 and 1993). The Dissertation Abstracts should be combined with other national dissertation databases to trace the SE diffusion. At present, there is no European dissertation database, but there is a strong EU-ambition to generate scientific bibliographic databases.

Cornell has produced 5 dissertations and Maryland College Park 3 dissertations; Anselin's at Cornell was the first dissertation on SE (1980) according to the database Dissertations Abstracts.

*4. Conclusions***.**

Spatio-temporal economics - to borrow an expression from theoretical physics - is certainly characterized by great complexity; we only refer here to some studies in potentialized - this aspect refers to the first principle, spatial interdependence, reported in part 2.3 - partial differential equations (Sarafoglou, 1987 and 1994, Kaashoek and Paelinck, 1994, 1996, 1998 and 2002) which lead to unexpected spatial patterns. Figure 2 shows one of them and compares it to spatial reality which is to be explained (figure 3).

Figure 2: complex dynamics simulated...

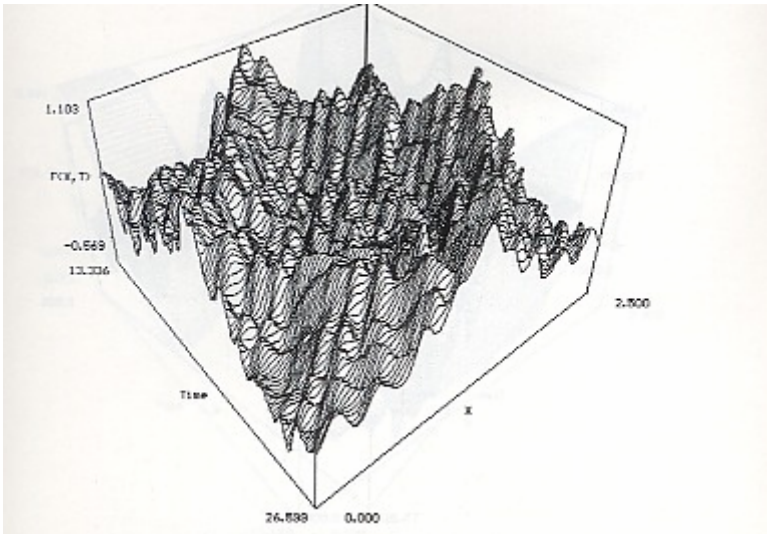

Figure 3: ...and spatial reality.

Interpreting those patterns starts with theoretical spatial economics and should flow into spatial econometrics, if theories are to confront the facts, possibly to be contradicted, at times to be relegated to the waiting room of theories pending there ever uncertain status. That this process is underway is shown by large groups of studies devoted to such objects as multiregional convergence or divergence (in terms of incomes per head, e.g.), testing alternative spatial theories (f.i. new economic geography against new urban economics), developing more appropriate ways of specifying spatial interdependence, generating adequate estimation procedures for the parameters implied by all these specifications.

These developments will aid to overcome the criticisms uttered at the beginning of part 2.1, regarding especially the use of regional models to underpin regional policy decisions; inappropriate models can only be expected to give inappropriate answers to policy questions, hence the necessity of correct spatial specifications[2].

Notes.

[1] Keynes (1940) wrote the following famous comment on Tinbergen´s econometrics:

"No one could be more frank, more painstaking, more free from subjective bias or parti pris than Professor Tinbergen. There is no one, therefore, so far as human qualities go, whom it would be safer to trust with black magic. That there is anyone I would trust with it at the present stage or that this brand of statistical alchemy is ripe to become a branch of science, I am not yet persuaded. But Newton, Boyle and Locke all played with alchemy. So let him continue."

The Keynes-Tinbergen debate generated many articles after the WWII-period. Many economists and econometricians demystified the debate (Theil 1963, Patinkin 1976, Stone 1978, and Hendry 1980). A good survey of the verae causae and references of debate can be found in Jolink (2004).

[2] One can ask the question what the potential impact of the field of SE may be on research and practice in the future?

SE has been applied in many fields e.g. economics, geography, real estate, planning, regional science, public policy, environmental studies, criminology, transport, agriculture, technology issues, biology, public health, political sciences, etc.

The citation analysis may help us to identify four most cited applications of SE:

1. Local spillovers
2. Housing prices
3. Regional income convergence
4. Deforestation

Other known SE-applications are:

* Population changes
* Macroeconomic fluctuations
* Air pollution
* Crime and residential choice
* Welfare distribution
* Water quality
* Public services
* Active labour market policy
* Elections results
* Commuter rail
* Mental health expenditure
* Dairy sector

The next question is how SE has been utilized by practitioners in real life.

To our knowledge, the determination of housing prices might be the most frequent application of SE by banks and real estate agencies.

A prediction for the SE-applications is that the diversity of the applications will be larger, and new fields like emergency studies (e.g. the chaotic climatic effects in the area of New Orleans) could utilize SE-methodology.

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