

**THE USE OF GAME THEORY
IN REGIONAL ECONOMICS:
A QUANTITATIVE
RETROSPECTIVE**

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The Use of Game Theory in Regional Economics: a quantitative retrospective

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Abstract

The construction of formal models that deal with space observed a huge increase since the late 1980s. As Fujita *et al.* (1999) stress, the field of regional economics experienced a revival with the emergence of new analytical tools such as the diffusion of imperfect competition models, networks and mathematical programming.

One of the most powerful tools within social science in general and economics in particular is game theory. This methodology allows for the formal analysis of the interactions among economic agents and, therefore, it is particularly useful for the study of economic decisions regarding spatial issues such as the location choices of firms and households; infrastructures, transports and communications; regional and urban policy; innovation and regional development; and regional labour markets. For this reason, a concrete, quantitative systematization of the use of this tool on regional economics research seems to be a relevant topic in the agenda concerned with progress in regional science.

In this paper we study research in regional economics and provide a quantitative retrospective of the use of game theory in this field. Our main goal is twofold. First, we intend to categorize the contributions in the use of this analytical tool - by main research subjects, by authors' affiliations, by journal, etc. - using a bibliometric approach. Second, by analysing co-authoring and using Social Network Analysis, we want to test the existence of structures upon which distinct co-authorship emerges.

In broader terms, the results of this research provide a framework for analyzing the potential use of game theory in regional economics, suggesting new future research directions.

Keywords: Regional Economic Methodology; Game Theory; Social Network Analysis; Bibliometry.

JEL-codes: R1; C7; D85.

1. Introduction

Since the late 1980s, the field of regional economics observed an important revival with the emergence of new analytical tools such as the diffusion of imperfect competition models, networks and mathematical programming (*e.g.*, Fujita *et al.*, 1999). With the support of these instruments, research in regional economics has become increasingly formalized.

One of the most powerful analytical tools within social science in general and economics in particular is game theory. This methodology allows formal analysis of interactions among economic agents in different information contexts and, therefore, it is particularly useful in the study of economic decisions regarding spatial issues such as the location choices of firms and households; infrastructures, transports and communications; regional and urban policy; innovation and regional development; and regional labour markets. Since all reasoning beneath this instrument is mathematical, it has strong and clear advantages in establishing the logical coherence of theoretical arguments. Moreover, it highlights the decision processes behind micro and macroeconomic dynamics while focusing on the search of equilibria solutions.¹ For this reason, a tangible, quantitative systematization of the use of this tool on regional economics research is a relevant topic on the agenda concerned with progress in regional science, namely regarding advances in regional economic theory related to game theory formalization.

This paper illustrates the more important emergent features in this research field from 1969 onwards, based on the analysis of a large dataset covering all articles published in economic journals with peer review procedures, gathered from the Econlit database over the past forty years. In order to identify the relevant research covering the regional field and game theory, a search procedure was used that covers not only the title and the abstract of the article but also its main text.

The paper is structured as follows. After an outline on the pioneer use of games within regional economics in Section 2, Section 3 details the bibliometric methodology underlying the study and its main results. In Section 4 a Social Network Analysis (SNA) is implemented in order to analyse the existence of co-authorship networks in this research field. Section 5 concludes.

¹ The use of mathematical models in economics has been strongly featured by methodological considerations. For the mainstream, this approach is crucial in order to attain logical coherence in theoretical reasoning (*e.g.*, Backhouse, 2000). So, game theory is widely recognized as an important tool in abstract theorizing.

2. Regional economics and game theory: a brief overview of the precursors

The stylized fact that economic activities are unevenly distributed across space is the basis for the development of regional economics in general and spatial economics in particular. Therefore, there is a fundamental decision-making process which is at the analytical core of these research fields: the choice made by some particular economic agents to establish themselves in some specific places, and the geographical organization of the economy that emerges from those decisions (Fujita and Thisse, 1996).

More recently, the so-called ‘new economic geography’ (e.g., Krugman and Venables, 1990; Krugman, 1991) has considerably improved the traditional explanations - focused on differences in endowments, technologies and policy regimes - for spatial differences in production patterns (Ottaviano and Puga, 1998). In fact, the ‘new economic geography’ constructed a novel perspective concerning location, stressing the idea that firms are likely to cluster together and that regions with similar original features may develop different trajectories (Ottaviano and Puga, 1998). By introducing interregional labour mobility, Krugman (1991) allowed agglomeration or, in general, the spatial distribution of economic activity, to become endogenous (Brakman and Garretsen, 2006).

Moreover, the new ‘economic geography’, by the strong connections established with several streams of modern economics such as industrial organization, urban economics, international trade, and growth and development growth theories (Fujita and Thisse, 1996), was crucial not only for revisiting the concept of agglomeration economies but also for the development of formal approaches within the broad field of regional economics.

The increasing formalization within regional and industrial economics is also associated with game theory, particularly in the study of interdependent decision-making processes by firms (Kylenny and Thisse, 1999). As Fujita and Thisse (1996: 343) stress, “The very nature of the process of spatial competition is (...) oligopolistic and should be studied within a framework of interactive decision making. This was one of the central messages conveyed by Hotelling (1929) but was ignored until economists became fully aware of the power of game theory for studying competition in modern market economies.”

The publication of the seminal book *Theory of Games and Economic Behaviour* by von Neumann and Morgenstern in 1944 was the trigger for the increasing and widespread use of game theory in economics. Regional economics was not an exception and has been

increasingly using this analytical instrument, which is particularly helpful in situations involving conflict of interests.

Based on a dataset gathered from the Econlit database from 1969 up to the end of 2009,² and after the analysis of the earlier articles, it is possible to conclude that the most important contributions concerning the use of game theory in regional economics emerged in the 1980s. Jacques Thisse and Simon Anderson are the precursor authors in this specific area, both with several articles in this research field and with seminal contributions during the eighties, which are systematized in Table 1.

Table 1 – The pioneer literature on the use of game theory in regional economics

Author (year)	Title	Journal (ranking*)	Research Topic
Fujita and Thisse (1986)	Spatial Competition with a Land Market: Hotelling and Von Thunen Unified	<i>Review of Economic Studies</i> , LIII. 819-841 (AA)	Spatial competition model with consumption of land by households; spatial competition under the influence of a land market.
Gabszewicz and Thisse (1986)	On the Nature of Competition with differentiated Products	<i>The Economic Journal</i> , 96 (March 1986), 160-172 (AA)	Fundamental features of horizontal versus vertical product differentiation. Analysis within location theory.
Anderson (1988)	Equilibrium Existence in the Linear Model of Spatial Competition	<i>Economica</i> , 55: 479-91 (B)	Generalization of the Hotelling model of spatial competition.
Thisse and Vives (1988)	On the Strategic Choice of Spatial Price Policy	<i>American Economic Review</i> , 3: 122-137 (AA)	Business practices arising in geographical pricing like the basing point system and in the pricing of varieties from a base product in the context of a product differentiation.
Anderson (1989)	Socially Optimal Spatial Pricing	<i>Regional Science and Urban Economics</i> , 19 (1): 69-86 (A)	Second best optimal spatial pricing schedules for a general class of demand functions.
Anderson and Neven (1989)	Market Efficiency with Combinable Products	<i>European Economic Review</i> , 33(4): 707-19 (A)	Product location-price game that allows consumers to combine products to obtain a mix of their characteristics.
Anderson, de Palma and J. Thisse (1989)	Spatial Price Policies Reconsidered	<i>The Journal of Industrial Economics</i> , XXXVIII: 1-18 (AA)	Three spatial price policies: uniform pricing, mill pricing and spatial price discrimination.

* The adopted ranking is described in the text.

Own elaboration.

² The methodology underlying the bibliometric exercise is described in Section 3.

From Table 1 we observe that the pioneer contributions are focused on location theory. This is not surprising since the research subject within this field involves, by itself, an interactive decision making process. In fact, as Duranton (2004) states, in spite of being concerned with the allocation of resources over space, the main focus of spatial economics is location choice. Additionally, as location choices (and other decisions involving space) are taken within market structures with a certain degree of monopoly, game tools are particularly useful for their modelling.

Thisse and Anderson seem to have a crucial role in importing game theory to regional economics, not only by contributing with original research but also by establishing important networks between regional science and other branches of modern economics such as industrial economics and microeconomics. Our analysis of co-authoring articles (see Section 4) will certainly bring some light on these potential interconnections. For this former time period, it is significant the joint work of the top-authors, Thisse and Anderson, with a common article (jointly with de Palma) published in 1989. By the end of the eighties, as it will be demonstrated in Section 3, the escalating of this research line is clear.

Finally, it is important to acknowledge that these precursor articles were published in very high quality journals, which brings a high status for the research in this area. In fact, and taking into consideration the Tinbergen Institute classification that ranks the journals in the fields of economics according to their impact factor (see Section 3), we may observe that pioneering work in this research area was published mainly in top (AA) or in very good journals (A).

3. A bibliometric approach to the use of game theory in regional economics: the methodology and main results

In order to characterize the use of game theory within the large field of regional economics, we present a quantitative analysis of forty-year history of this last research stream.

For our bibliometric study, we propose a categorization of a large dataset gathered from the Econlit database from 1969 up to the end of 2009.³ The database was constructed using in

³ The American Economic Association provides an electronic bibliographic database of economic literature throughout the world – EconLit, which provides bibliographic information concerning the international literature on economics since 1969. A broad range of document types published worldwide is covered, mainly journal articles.

simultaneous two terms as search keywords: ‘game’ and ‘regional’. The search procedure is encompassing since the search covers the keywords in several dimensions: the title, the abstract and the main text of the articles. Although we recognize the limitations behind bibliometric exercises concerning the choice of the search keywords, we consider that the selected keyword combination - ‘game’ and ‘regional’- is able to capture the core of the contributions in the area under scrutiny.

Our dataset encompasses a total number of 6262 records. Since we want to focus only on research contributions, we neglected articles corresponding to comments, rejoinders, book reviews and *corrigendas*. Moreover, as already mentioned, we limited the search to peer reviewed published articles.

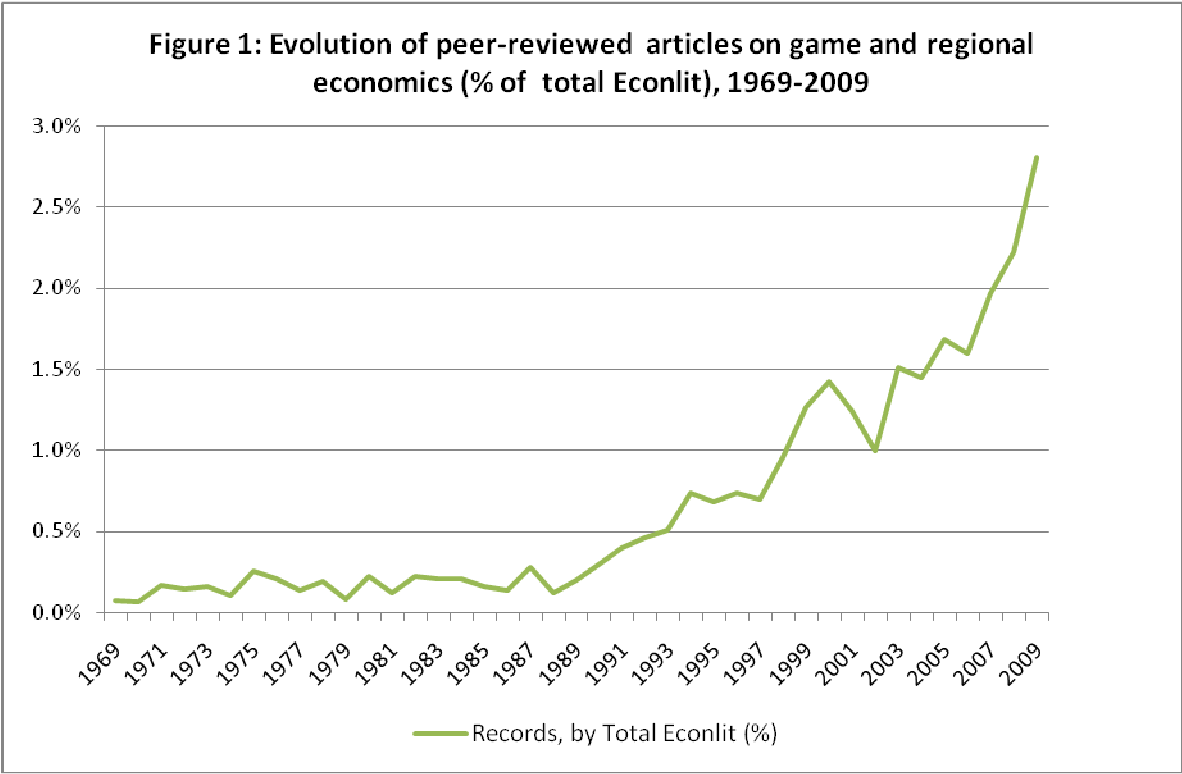
Our bibliometric analysis is an effort to uncover the main research paths that the use of game theory within regional economics has actively pursued and reinforced throughout the last forty years. In this context, we propose a categorization of all articles concerning distinct dimensions. For each article, we account for the geographic area of the institution authors are affiliated (NA - North America (USA and Canada); EU – Europe; A – Asia; and the residual category O - Other geographical origins). The categorization of each article is also made in terms of their research themes, mainly based on the Journal of Economic Literature (JEL) Classification System.⁴ However, for all the articles categorized in the JEL classification as *R - Urban, Rural, and Regional Economics*, we also implement an additional characterization based on a particular typology proposed by Ottaviano and Minerva (2007: 437). This typology considers six categories: 1) regional science, input-output models; 2) regional and urban economics; 3) spatial competition, location theory, monocentric-city models; 4) economic geography; 5) econometric regional models, spatial econometrics; and 6) experimental economics.⁵

⁴ The *JEL classification system* is a very straightforward procedure to categorize research in economics. Therefore, we follow this system in order to account for the main research paths within our database.

⁵ The authors provide a detailed explanation concerning these categories. For instance, in what concerns “regional science” and “regional and urban economics”, the distinction is based on the microeconomic foundations since the latter category is based on optimizing agents and the former is not. Specifically, papers categorized in the JEL classification as R10, R11, R12, R13, R21 and H71 are included in “regional and urban economics” (Ottaviano and Minerva, 2007). Moreover, “[t]o “spatial competition, location theory, monocentric-city models” belong the articles in which distance among locations in space has a geometric formalization (usually in terms of Euclidean distance). This may also apply to spaces that are not physical, such as the space of characteristics in product differentiation theory. Accordingly, some [(...)] contributions fall into the domain of Industrial Organization. Papers in “economic geography” simultaneously study trade in goods and where factors of production locate. Articles in “econometrics” are either empirical works, involving simply some statistical estimation, or works presenting new insights in econometric theory applied to spatial phenomena. The discipline

We also propose a quantitative selection of all the articles according to the ranking position of the journal where they are published and a counting of the top-authors (those with the highest number of published papers) in a pre-selected time period.

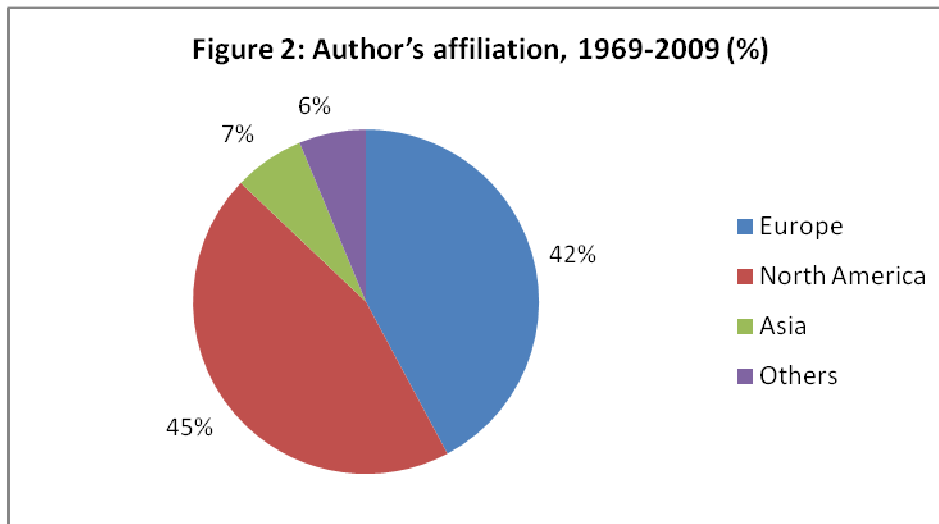
The bibliometric exercise uncovers the main research paths over the last forty years associated with the use of game theory in regional economics. After the influential work of Thisse and Anderson documented in the previous section, the use of game theory in regional economics observed a significant increase. As Figure 1 shows, there is an escalating of this research line since the final eighties. Before this date, the relative importance of published papers in the research area under scrutiny was very low (0.1-0.2% of total EconLit). More than 95% of the total articles were published only after 1990.



Own elaboration.

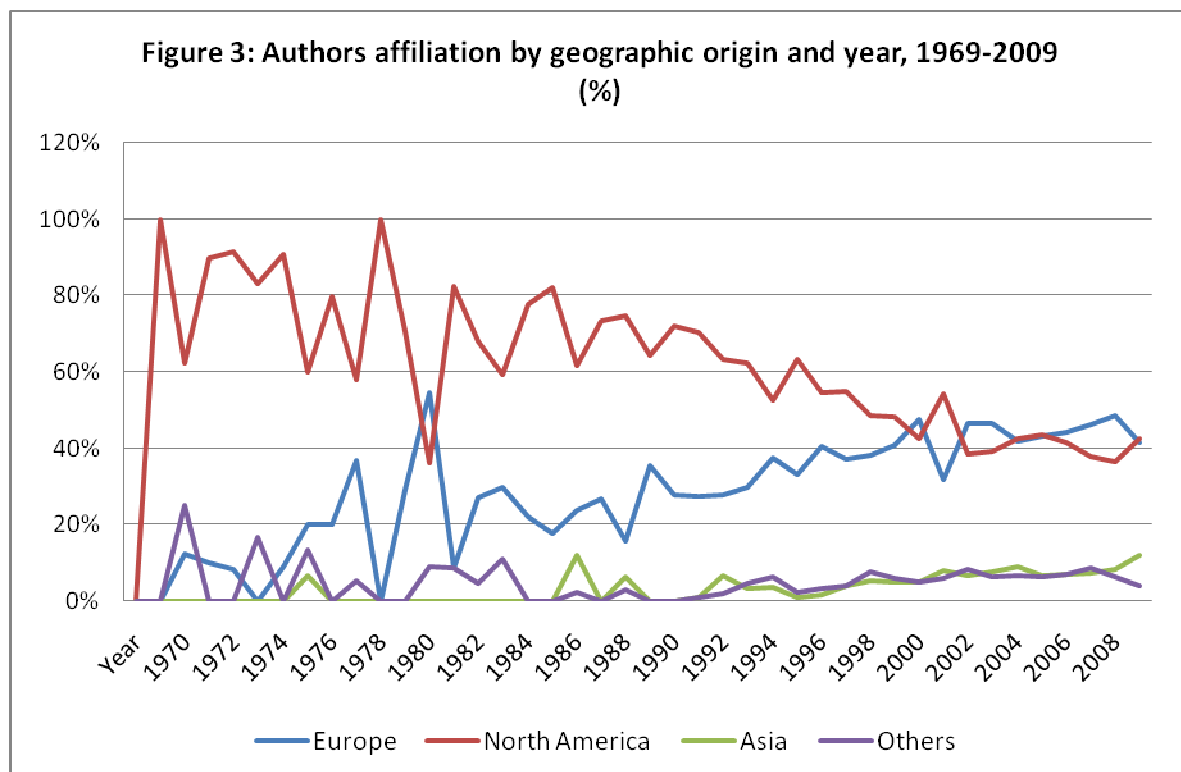
Taking into consideration the geographic area of the institution authors are affiliated, it is clear the relevance of North American researchers. In Figure 2, almost half of total researchers that contributed with published work during the forty years under study are from North America.

of “experimental economics” is added for completeness, even though experiments are very uncommon in regional and urban investigations.” (Ottaviano and Minerva, 2007: 437).



Own elaboration.

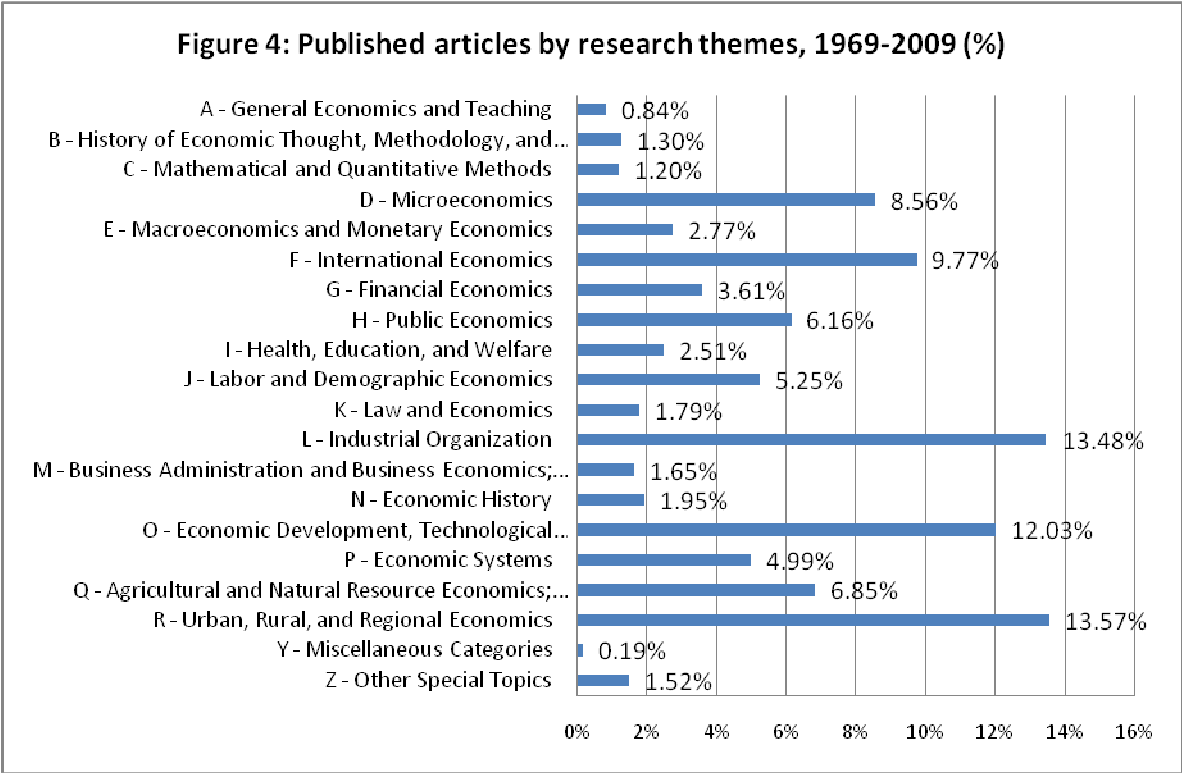
However, the analysis of the research path through time reveals an important change in terms of the geographical origin of the researchers. In fact, in the beginning the data shows that most published work was made by North American authors, with a relative importance of more than 60%. This composition is maintained until middle 1990s. Since then European researchers have been gaining weight and, at the moment, each of these geographical groups account for almost 45% of total research (see Figure 3).



Own elaboration.

In terms of research areas, the quantitative analysis reveals that, besides *Urban, Rural, and Regional Economics*, the most investigated topics are *Industrial Organization* and *Economic Development, Technological Change, and Growth*, respectively with 13.5% and 12.0% of total research produced during 1969-2009 (see Figure 4). A potential explanation for this pattern is associated with the fact that seminal authors in game and regional economics related research, such as Thisse and Anderson, develop research both in industrial and spatial economics (e.g., d' Aspremont *et al.*, 1979; Anderson *et al.*, 1992).

Some topics that apparently may establish important connections with regional economics such as *Public Economics, Labor and Demographic Economics* and *Health, Education, and Welfare*, are poorly represented in this distribution. This might reveal the less importance of location decision-making within these fields and so the disregard of strategic interaction behaviour between economic agents.

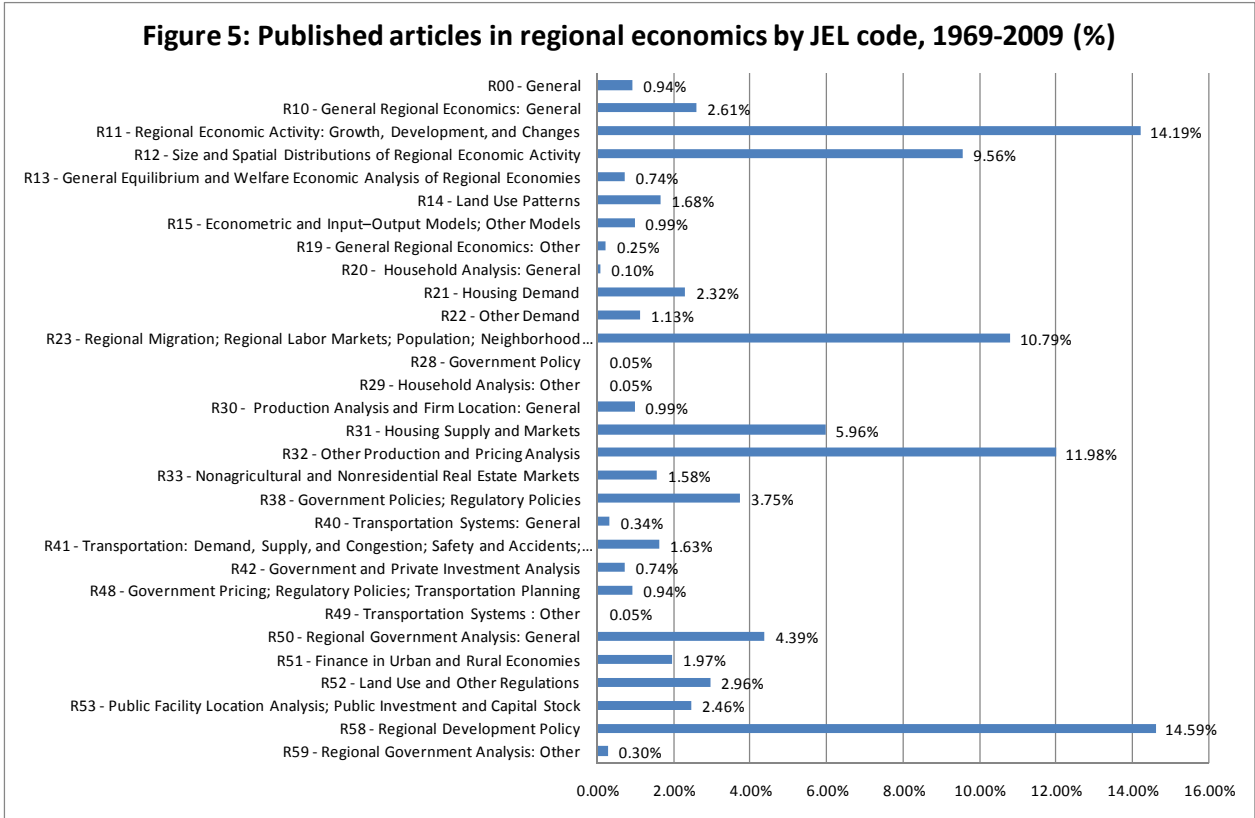


Own elaboration.

In what concerns the specific research area of *Urban, Rural, and Regional Economics* (Figure 5) one of the main topic is *Regional Development Policy*, accounting for 14.6% of total research. Other relevant themes are *Regional Economic Activity: Growth, Development, and*

Changes (14.2%) and *Size and Spatial Distributions of Regional Economic Activity* (9.6%). Ottaviano and Minerva (2007), focusing on the publications on the *Regional Science and Urban Economics* (RSUE) during its thirty-five years, also highlight the relevance of these two last subjects. This is not surprising since these themes are cornerstones in regional and urban economics.

As we have stressed before, location models involve the analysis of strategic behaviour. Hence, game theory appears as a very suitable instrument for modelling location choice. So, the themes on *Production Analysis and Firm Location* are very well represented.



Own elaboration.

We also analyze the distribution of articles by authors in the research area. For that purpose, we examined the number of published articles *per* author. As we can see in Table 2, the research in the field is highly disperse since most authors (83,8%) only have published one paper. Additionally, only 58 authors have five or more publications in the area, in a total of 7622 researchers.

Table 2– Distribution of authors, by class of articles

Number of articles	Number of authors
Publications \geq 10	2
$8 \leq$ Publications $<$ 10	7
$6 \leq$ Publications $<$ 8	20
$4 \leq$ Publications $<$ 6	121
$2 \leq$ Publications $<$ 4	1084
Publications = 1	6388
Total	7622

Own elaboration.

To offer a first glimpse on the most relevant authors in game and regional economics related research, we identify the top-authors in terms of the number of publications, *per* decade (Table 3).

Table 3 – Top authors in the regional and game research field

Top Authors	
1969-1979	Number of records
Benston, George J.	2
Willett, Thomas D.	2
1980-1989	
Thisse, Jacques	5
Anderson, Simon P.	4
Kane, Edward J.	3
Hopkins, A. G.	3
Cain, P. J.	3
Newman, D. Paul	3
1990-1999	
Batabyal, Amitrajeet A.	5
Anderson, Simon P.	4
Smith, Ron	4
Eichengreen, Barry	4

McAfee, R. Preston	4
2000-2009	
Roth, Alvin E.	10
Matsumura, Toshihiro	8
Baade, Robert A.	7
Heywood, John S.	7
Lindroos, Marko	7
Garcia-Alonso, Maria del Carmen	7
Matheson, Victor A.	7
Pontes, Jose Pedro	7
Weiler, Stephan	7

Own elaboration.

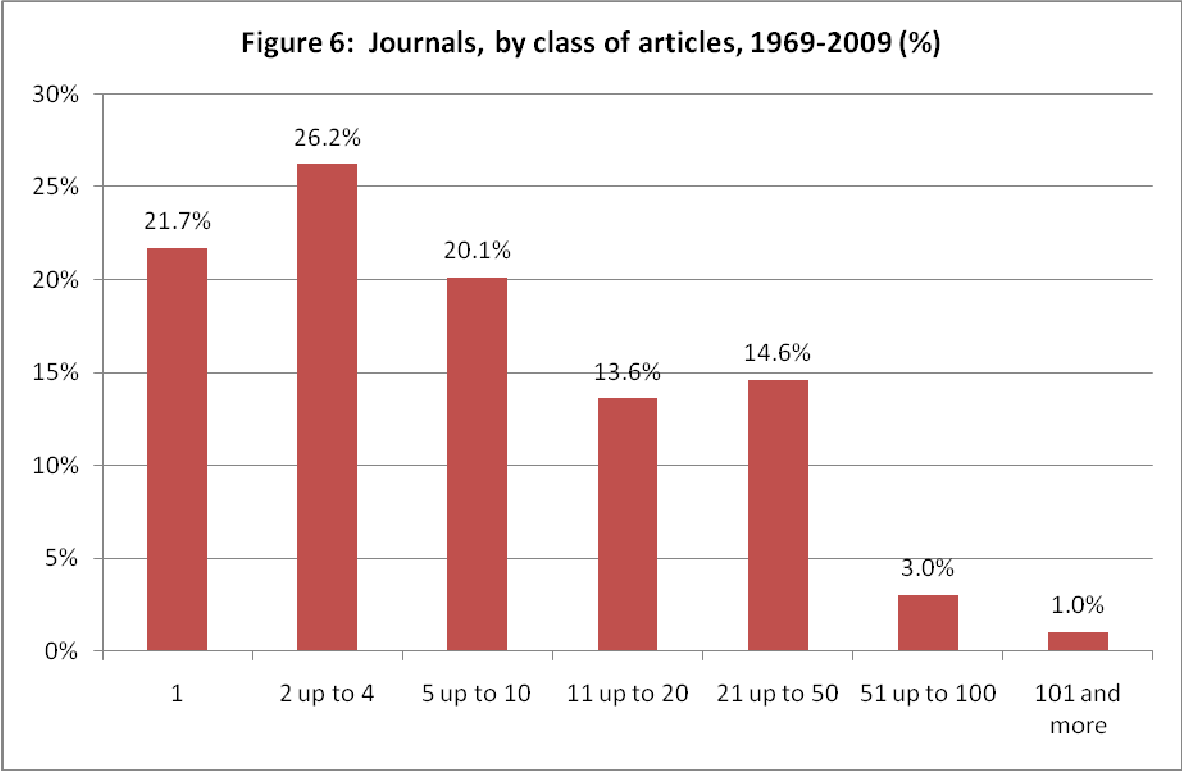
The critical contributions emerged since the eighties with the pioneer work of Thisse and Anderson, already discussed in Section 2. More recently, Roth, with 10 articles published in the 2000-2009 period, mostly working with asymmetric information and bargaining theory (*e.g.*, Roth *et al.*, 2007), is highly representative of the growing importance of formalization within regional economics. Moreover, he has been developing important work on the spatial dimension of health related topics (Roth, 2007, 2008) and on experimental economics (Roth, 1991).

In Section 4 we study the importance of research relationships between the authors publishing in the area, by examining co-authorships on the articles that compose our database. As we will see, the implementation of Social Network Analysis methodology allows us to identify potential networks in the field.

Finally, we intend to offer an appraisal concerning the quality of the research that has been published since 1969 until 2009 in the game and regional economics research area. For that purpose, we construct a ranking of the journals indexed in the EconLit database by using the impact factor published by RePEc in May 2010 and also the classification system developed by the Tinbergen Institute⁶.

⁶ The classification system developed by the Tinbergen Institute ranked the journals in the field of economics as: AA: top-level journals, with and impact factor (IF) higher than 3; A: very good journals with IF higher than 1.5; B: good journals, with IF higher than 0.3. Following Silva and Teixeira (2008), we considered three other categories, C with IF > 0.1, D with IF lower than 0.1 and and NC: journals that are not ranked (in RePEc or the Tinbergen Institute ranking).

We start by looking at the importance of the several journals for this particular topic (Figure 6). The results evidenced that, from the total 508 journals that published an article within this research area, about 21.7% only published one article and about 68.0% published no more than 10 articles, while about 1% of the journals published more than 100 articles in the topic we are studying.



Own elaboration.

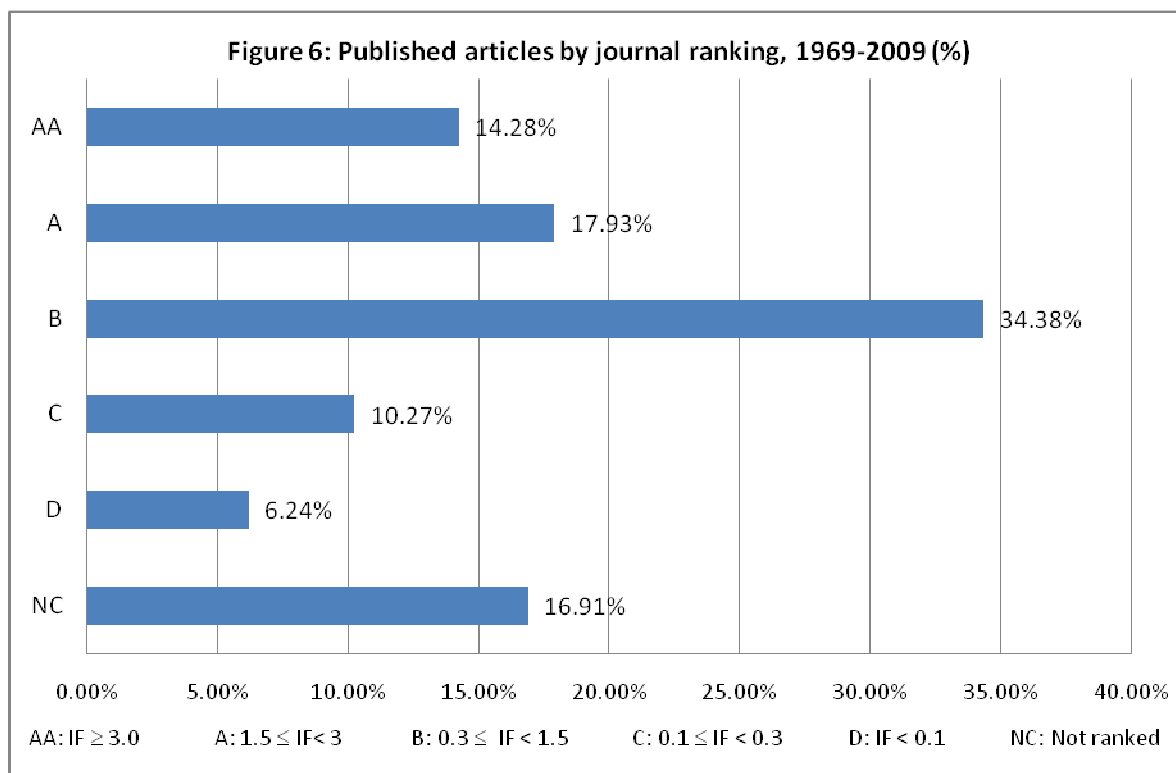
The list of the most relevant journals for game and regional study is presented in Table 4, with *Urban Studies* in the top position, besides other publications that are mainly linked to the spatial topics (e.g. *International Journal of Urban and Regional Research*, *Regional Studies*) or others non-specific but highly ranked journals (e.g. *American Economic Review*, *Economic Journal*). We also include a journal ranking that allows us to conclude, in a first glance, for the very good quality of the research in the area.

Table 4 – Top journals in regional and game research

Journal	Number of articles	Journal ranking
Urban Studies	279	B
International Journal of Urban and Regional Research	123	C
Public Choice	118	A
Regional Studies	118	B
Journal of Common Market Studies	107	B
Development and Change	95	B
Journal of Economic Issues	83	C
American Journal of Agricultural Economics	76	B
New Political Economy	67	B
Journal of Environmental Planning and Management	61	C
American Economic Review	59	AA
Policy Sciences	59	D
World Economy	57	A
Review of International Political Economy	55	B
Housing Studies	54	B
Journal of Regional Science	54	A
Development Southern Africa	53	NC
Economic Journal	51	AA
Journal of Economic Literature	51	AA
Problems of Economic Transition	51	D
Journal of Economic Perspectives	50	AA
AA: $IF \geq 3.0$ A: $1.5 \leq IF < 3$ B: $0.3 \leq IF < 1.5$ C: $0.1 \leq IF < 0.3$ D: $IF < 0.1$ NC: Not ranked		

Own elaboration.

This first insight is also confirmed when we consider the total dataset (Figure 6), as the relevance of top (AA) and very good (A) journals for the regional and game research accounts for about 14.3% and 17.9% of total research, respectively. We may also note that the percentage of papers that are published in non-ranked journals is also quite significant (16.9%).



Own elaboration.

Finally, we develop a co-citation quantitative exercise in Section 4 to investigate potential networks among researchers. This last procedure aims at investigating the potential existence of solid, interrelated subgroups of relatively strongly connected scholars, and the implications of this for the structure of the research field in analysis. All this documentation effort aims at offering a rigorous account of the use of game theory in regional economics in the past forty years.

4. Testing the existence of co-authorship patterns: a social network analysis

In order to approach the existence of communication patterns of scholars, we focus on a particular product of scholarship – co-authorships. By using the social network analysis (SNA), we are able to show the existence of network structures created between authors through the last decades.

According to Freeman (2004), the social network approach is grounded in the intuitive notion that the patterning of social ties in which actors are embedded has important consequences for those actors. By following this idea, this technique permits to discover some cohesive groups

between authors and associates them with specific sub-themes, geographic origin and decade of publication. Hence, we start with a brief presentation of the methodology and we then systematize the main results.

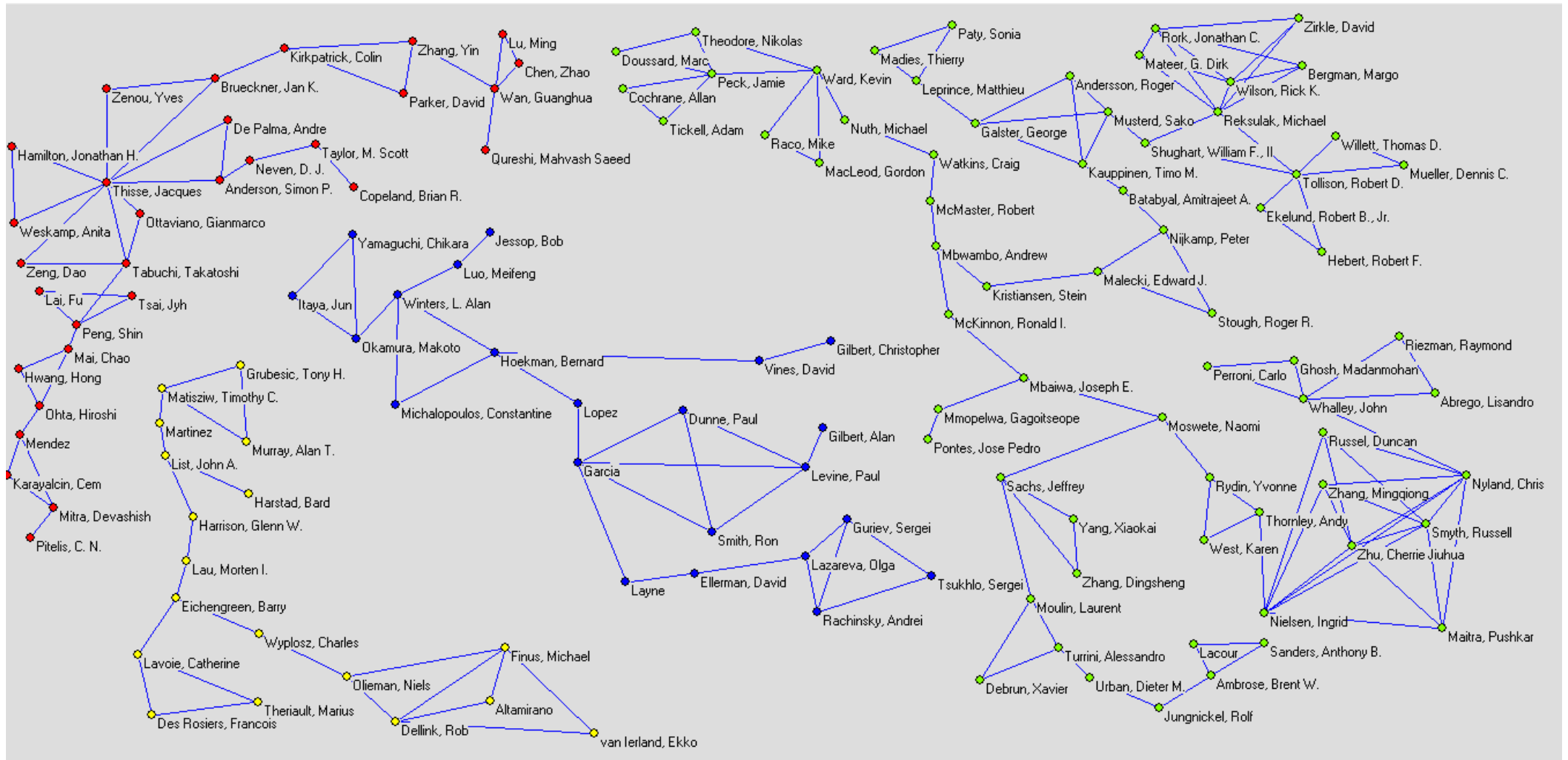
After the creation of an extensive network based on our database (using the Pajek⁷ software), we identify and analyse the main components in this network. Using Scott's (2005) terminology, a *component* is a maximum connected sub-graph, *i.e.* it is impossible to add new members without destroying the connection quality. On the other hand, a *k-core* is a maximum sub-graph in which each point is adjacent to at least k other points.

Following the methodology presented by de Nooy *et al.* (2005), in order to identify the most important groups, we remove the least dense vertices from the network, using the k -core tool available in Pajek, and determine what components with 10 or more elements are formed within it. After removing all that points (about 2629 vertices), the components within this network are then determined, as it is represented in Figure 7.

From Figure 7 it is possible to show that there are four big components in the network, with the green one being significantly higher in the number of vertices relatively to the others. In order to separate the authors associated with each group, further analysis on the potential reasons (sub-themes, geographic origin and decade of publications) that could explain this relatively high groups' cohesion is developed. With this aim, we analyze in detail the main components in the network.

⁷ Pajek is a free program, for Windows, for analysis and visualization of large networks, created by Vladimir Bagatelj and Andrej Mrvar.

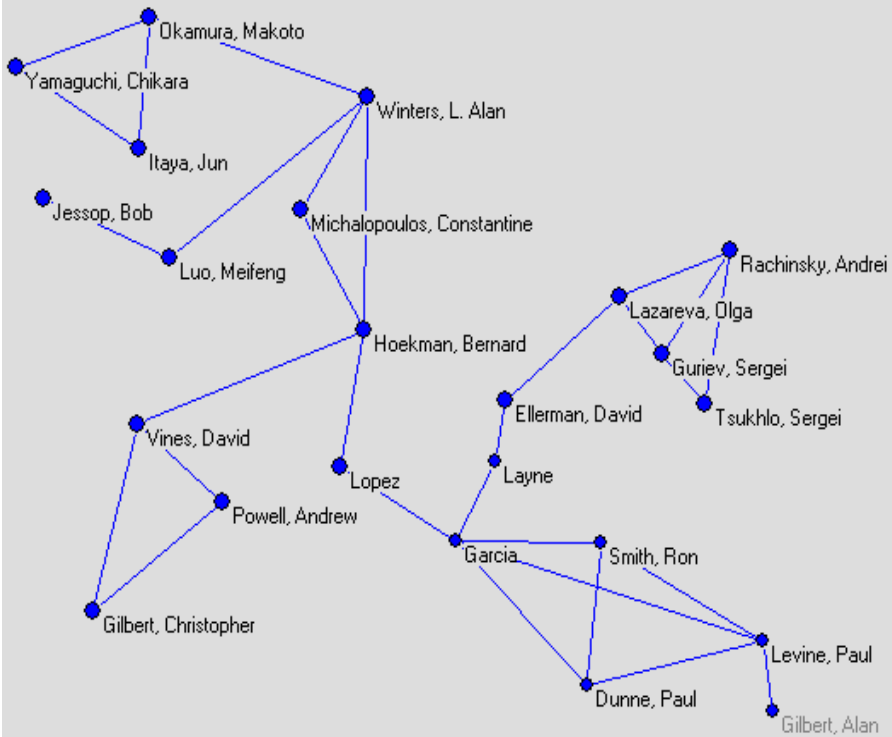
Figure 7 – The main components in the network



Own elaboration.

The blue component, also represented in Figure 8, is a relatively large group, composed mostly by European authors that started appearing only in the 1990s, increasing substantially in the first decade of the new millennium. This group approaches themes mostly focused on *Economic Development, Trade and Public Policies*. Moreover, centrality tools point at Bernard Hoekman as the most influent agent in this blue component since he is considered a centre⁸ and has the highest levels of *closeness* and *betweenness* centrality.⁹

Figure 8 - Blue component



Own elaboration.

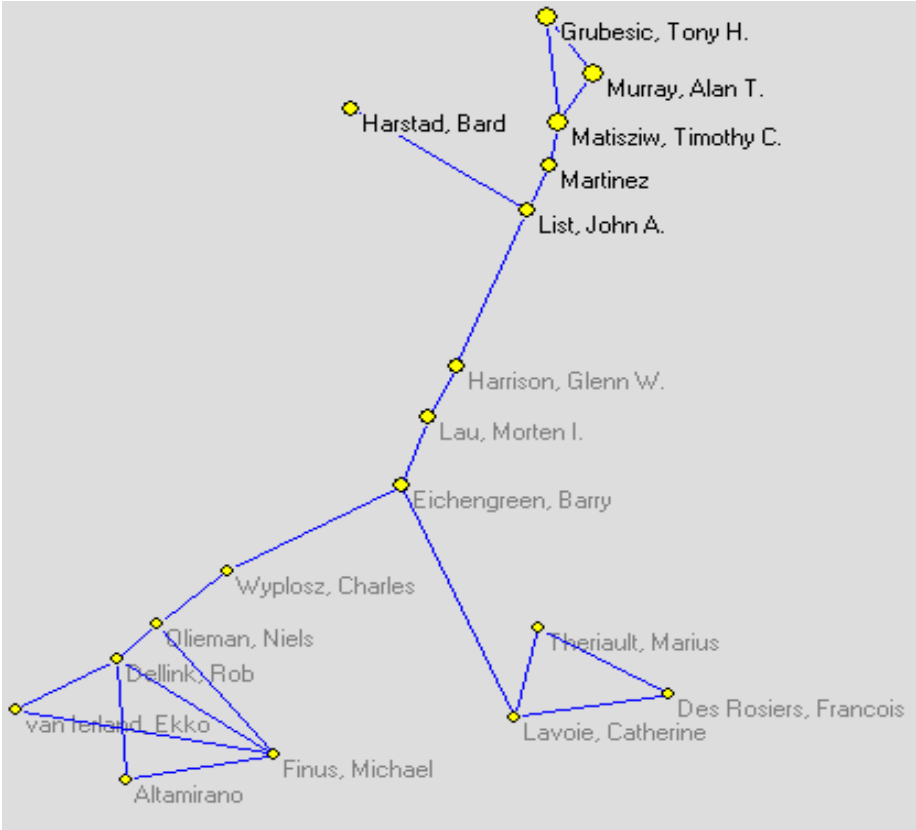
In Figure 9 we represent the yellow component in the network. This one is rather peculiar in terms of the research theme because there is no other significant group dealing with its most relevant issues, like *Environmental Economics, Analysis of Collective Decision Making and International Finance*. Regarding geographic distribution, this component only contains

⁸A *centre* is a central node taking into account a “robbery” algorithm, i.e. according to Batagelj and Mrvar (2010), the vertices that have higher degrees than their neighbour steal from them.

⁹ In sociometrics there are two major centrality measures: *closeness* and *betweenness* centrality. The first one is defined by the number of other vertices over the sum of all distances between the vertex and all the others, which, according to Casey and McMillen (2008), defines an actor’s ability to access independently all other members of the network and, consequently, to spread information quickly throughout the network. The latter is defined by the proportion of all geodesics between pairs of other vertices that include this vertex, which reflects the number of people who a person is indirectly connecting through their direct links.

European and North-American authors, revealing an equilibrium between both. Moreover, this group appears very modestly in the 1990s, increasing very significantly in the last decade. By looking at the network structure of the yellow component, we may see that Barry Eichengreen, Glenn Harrison and Morten Lau are the central agents that is, those authors that connect the sub-group located above to the one located below.

Figure 9 - Yellow component

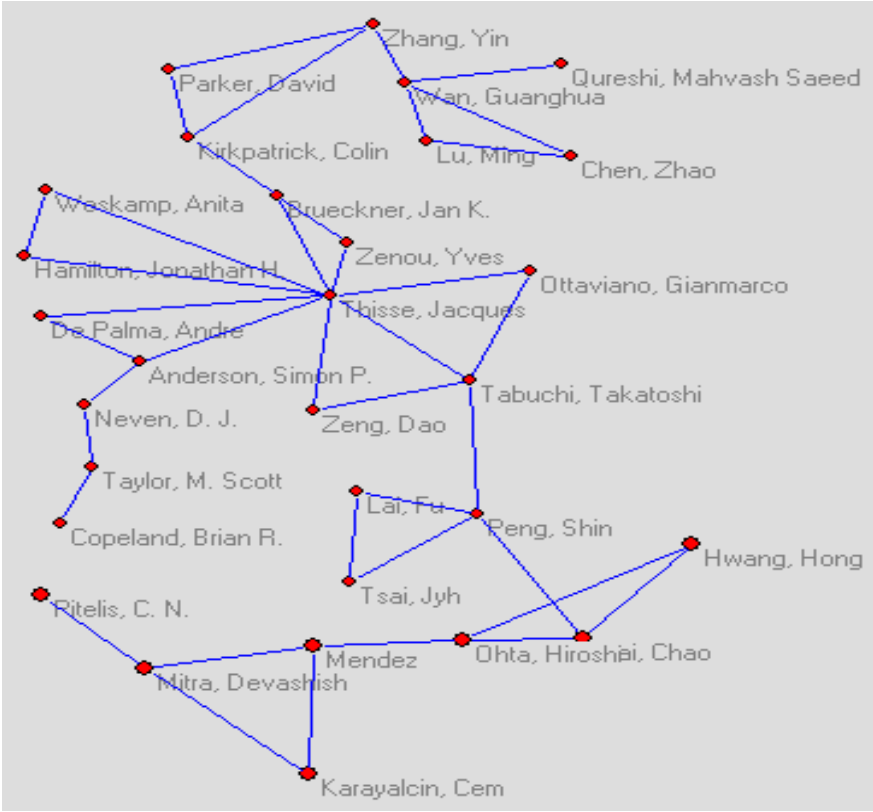


Own elaboration

The red component is probably the perfect portrait of globalization and of borderless ideas transfer that have been quite intensified in the last decades. In fact, in relation to the geographic origin of the authors, there is an almost perfect equilibrium between European, North-American and Asian authors. This group started earlier, in the 1980s, comparing with the other components. In the 1990s, the group was consolidated and, in this last decade, the global cooperation kept on rising. Regarding the themes in analysis, a pattern more focused on *Microeconomics* and a special attention to firm decision and markets, always within a regional context, is visible. Lastly, this component is very particular in what concerns the

central agent since all measures point to the same name: Jacques Thisse. The renowned author that had been referenced in Section 2 appears in this component with an indisputable position.

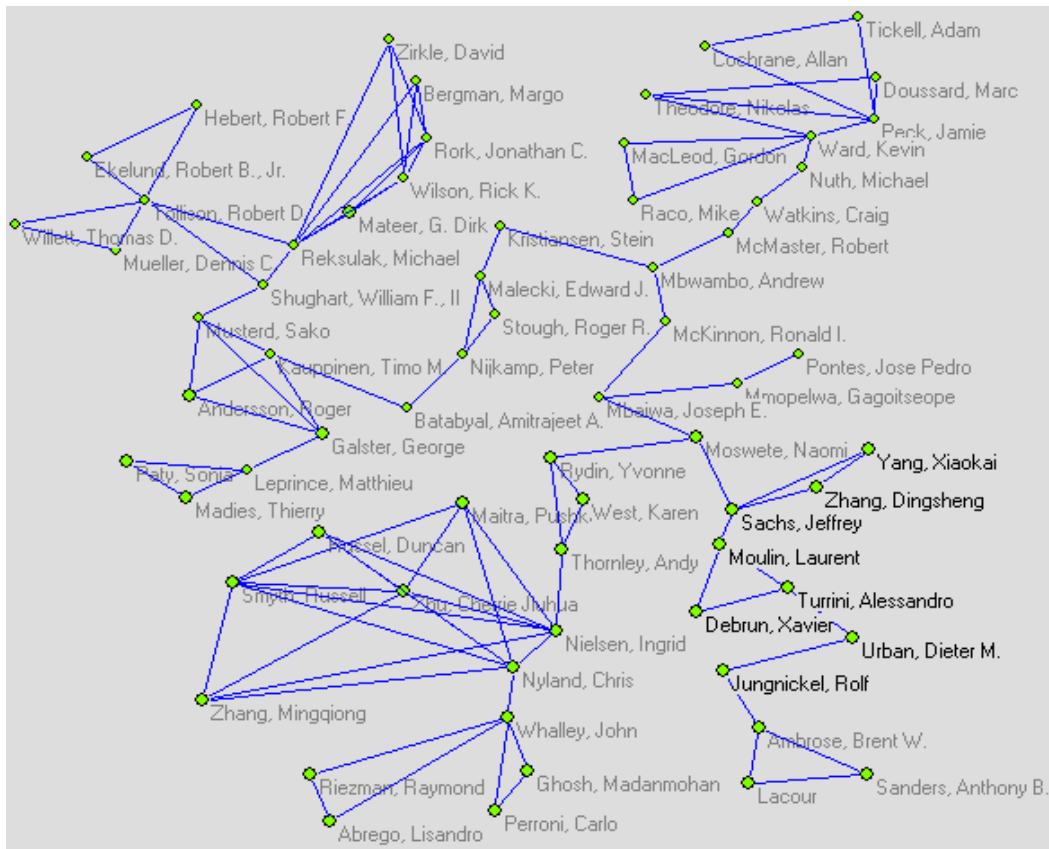
Figure 9 - Red component



Own elaboration.

At last, the green component, despite its huge dimension, shows a concentration of European and North-American authors, although with some European superiority. Concerning the temporal publishing evolution, the component presents a peculiar behaviour because this group appears in the 1970s, do not publish in the 1980s, appearing again in the 1990s and growing exponentially in the last decade. Regarding the research themes, beyond focusing on the state behaviour towards regional development policies and firm and market behaviour, these authors deal with renewable resources issues. Moreover, in this group in which there are some renowned authors as Peter Nijkamp, Andrew Mbanwanbo appears as the most central agent, presenting the highest indicators of *closeness* and *betweenness* centrality.

Figure 10 - Green component



Own elaboration.

Hence, the SNA implemented in our database allows a more concrete and measurable picture of a formal channel of communication among authors (co-authorship), which may be helpful to understand why the field in analysis has been carrying out research within certain themes and obeying to a certain organization, namely in what concerns geographical spreading of this knowledge.

6. The research agenda of game theory in regional economics: main conclusions

According to Fujita and Thisse (2002), to understand the spatial distribution of economic activities, and therefore, to account for space in economic modelling, we must adopt at least one of the following assumptions: *space is heterogeneous*, as in comparative advantage models or in pioneering static location models; *markets are imperfect*, as in spatial competition theory or in monopolistic competition models with increasing returns; or there

are *externalities* in production and/or in consumption, as in externality models. The use of the game theory to model decisions regarding regional analysis is, therefore, a quite suitable tool as it allows accommodating the interaction between agents that is intrinsic to most decisions concerning space.

As a result, game theory is an approach increasingly used in regional economics. This is evidenced by the escalating of publications in the regional and game research fields, but also by the high average quality that this research area evidences. Additionally, we found that most relevant research in the area is produced by few authors, suggesting that we should test the existence of networks and groups within this research area. Another relevant result is the increasing importance of European contributions. In fact, at the beginning, the North-American authors dominated the research in this field, but the European authors are gathering importance.

By analyzing co-authoring, using Social Network Analysis, we were able to show the existence of some cohesive groups between authors, which evidences the network fragmentation and the concentration around some key researchers. These groups differ not only in terms of selected research themes but also, and more interestingly, in terms of chronological publication behaviour and author's geographic origin. Second, European authors tend to occupy the most relevant position in the network - as in the case of Jacques Thisse in the red component - which can reflect in some extent the ability of European authors in developing network effects, namely through co-authorship.

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