Assessing local knowledge dynamics: Regional Knowledge Economy Indicators

Francesca Affortunato, Edgardo Bucciarelli, Mariateresa Ciommi, and Gianfranco Giulioni

Abstract—The paper represents a reflection on how to select proper indicators to assess the progress of regional contexts towards a knowledge-based society. Taking the first research methodologies elaborated at an international level (World Bank, OECD, etc.) as a reference point, this work intends to identify a set of indicators of the knowledge economy suitable to adequately understand in which manner and to which extent the territorial development dynamics are correlated with the knowledge-base of the considered local society. After a critical survey of the variables utilized within other approaches adopted by international or national organizations, this paper seeks to elaborate a framework of variables, named Regional Knowledge Economy Indicators (ReKEI), necessary to describe the knowledge-based relations of subnational socio-economic contexts. The realization of this framework has a double purpose: an analytical one consisting in highlighting the regional differences in the governance of knowledge based processes, and an operative one consisting in providing some reference parameters for contributing to increasing the effectiveness of those economic policies aiming at enlarging the knowledge bases of local societies.

Keywords—knowledge economy, knowledge society, information society, regional innovation system, territorial competitiveness, local development.

I. INTRODUCTION

THE immaterial, in the form of individual's knowledge, has been gaining importance in economic theory as a determinant of economic growth and structural change of economics systems.

However, the difficulties in fully characterizing the concept of knowledge make it hard to identify knowledge dynamics and to understand how they affect both growth and the qualitative components of economic development even when the focus is shifted at the local level.

For this reason, the analysis of the topic follows an indirect approach rather than a direct one. In other words, the impossibility to exactly measure knowledge inputs and the inability to find out their mathematical relationship with the economic outputs (to specify a production function) force scholars to screen all the features of a society to select those ones shaping the relationship between knowledge and economics. The outcome of this process is a list of socio-economic aspects that can be measured by a set of indicators. Some of them represent preliminary conditions necessary for the diffusion of knowledge rather than being a knowledge component of the society or of the economy.

This paper aims at identifying such a set of indicators by selecting in particular those aspects that are relevant at a local geographical level.

All the authors are with the Department of Quantitative Methods and Economic Theory, University "G. d'Annunzio" of Chieti-Pescara, Italy.

The paper is organized as follows. In section II we report the existing literature on the definitions of "knowledge economics" and on the attempts of measuring knowledge on the basis of sets of indicators and indexes. The improvements obtained by shifting the focus on measuring local knowledge are highlighted in section III. In section IV we describe the methodology used to select the variables. The sets of selected variables are reported in section V. Beside variables, it is useful to have a set of summary figures able to give a fast understanding of the phenomenon. We do this in section VI where a sort of benchmarking between a local context (data are from the Abruzzo Italian region) and the Country level is performed by means of a radar graph. This could help policy makers in choosing strategies for developing the knowledge bases of local societies. Section VII concludes the paper.

II. RELATED LITERATURE

A. A definition for Knowledge economy

When one tries to offer a measure of the level of diffusion of knowledge in a region through a few summary indicators, one of the major problems to be addressed is to provide a substantial definition of knowledge. It is from this definition that one chooses the determinant profiles (and thus indicators) able to represent and measure the process of knowledge spreading.

The focus on formulating a definition of knowledge implies an identification of the complexity of the phenomenon itself in its dynamic aspects referred to the context. The measurement aims to accuracy and systemic operation. The challenge when one tries to develop indicators like these is that of having concept and measures reconciled.

As from the industrial revolution, modern economy has been characterized by the production of value especially due to the spread of available knowledge and to the investments in the creation of new knowledge. In order to understand how economic value is created by stimulating new knowledge, it will be necessary to investigate the real dynamics of economic growth. It appears clear that we are in presence of a conceptual revolution, in which the vision is moved from the production process to that of propagation (Rullani, 2002 [17]). Moreover the conception of knowledge economics has a particular meaning: the rank in which knowledge is placed in economic processes (Pilati and Perrucci, 2005 [16]). First of all, knowledge economy refers to the economic-cognitive system on the whole. In addition the leading role is not only played by Schumpeterian innovators, but also by everyone who learns something new that, sooner or later, is

World Academy of Science, Engineering and Technology
International Journal of Economics and Management Engineering
Vol:4, No:7, 2010

going to produce a positive result for the economy. Among other things, scientific and technological processes, codification and reproduction of knowledge, rules of intellectual property become most relevant. Knowledge economy rests on social and cultural system, which is behind the single organization engaged in the innovation activities. Knowledge production could be perceived as a social process, to whom different functions and institutions contribute, at a local level more than elsewhere. Most of the available knowledge derives from this system which has been built by past generations: it has required massive investments mostly become sunk costs. These generate positive externalities to potential innovators advantage. Indeed knowledge is originated from the past and it is spread into the future. Then it passes through the present and it grows again: its dynamics do not only respond to an utilitarian aim, but also to other purposes. In an economic view, knowledge could also be observed as a decisive input of production and of firms organization, as well as an essential element of change management in the perspective of human capital (Noam, 2005 [15]). By highlighting the economic features of knowledge (such as no scarceness, no exclusiveness in its usage, problematic measurability and further more) it is showed a growing trend that knowledge has had during the time: both as a product and as a quality of the work-force. Another contribution focuses its attention on the contradiction between the increasing role of knowledge as an input of production and the imposition of restrictions to its diffusion due to copyright regulation (Gille, 2005 [10]). Others classified knowledge under a management perspective: in an operative form it refers to knowledge owned by workers which represent human resources of the firm; in a theoretical form knowledge is used by managers in order to define the position of the firm and to prepare decisions which concern investments, production and partnership (Volle, 2005 [21]). Another analysis examines knowledge under a new perspective: an interpretative one. It shows embedded, embodied, encultured and embrained knowledge (Blackler, 1995 [3]). Furthermore, the aim of knowledge economy is the enquiry and the discussion of institutions, technologies and regulation systems that could make the production and the use of knowledge easier. Knowledge as an economic good is not able to adequately renew itself and spread (Foray, 2006 [7]). Finally, knowledge economy, as a branch of learning, has an implicit prescribed function: it plays an important role in the creation of value by affecting local development (Rullani, 2002 [17]).

B. Attempts to measuring Knowledge economy

Since some economists, in the 90s, introduced the concept of knowledge-based economy (KBE hereafter) (Foray and Lundvall, 1996 [8]; Abramowitz and David, 1996 [1]), the scientific community tried to understand if such a generic and indefinite concept as that of "knowledge based" of a socio-economic system could be measured (Australian Bureau of Statistics, 2002 [2]; Foray, 2006 [7]; Leydesdorff, 2005 [13]; Cooke and Leydesdorff 2006 [6]; Godin, 2006 [11]). Godin, for example, comes to the conclusion that the development

of specific indicators failed because the concept of KBE is nothing but a rhetorical artifice, brought to success by international organizations, OECD firstly, whose objective was that of developing new conceptualizations of impact, which could attract the attention of policy makers, rather than ideas accurate from a scientific point of view.

In a different way from the concept of new economy, which derived from statistical workscand found there a definition, the concept of KBE (not as it appeared in the 60s, but in his renewed form of the 90s) "has nothing to do with numbers and everything with politics" (Godin, 2006 [11]). It was often pointed out how knowledge has always been important to economy and how its increased incidence and its use in socio-economic systems is taking place with a slow and gradual evolution (Foray, 2006 [7]); and it was also noted that the indicators proposed to measure the KBE, is actually able to capture neither the shape nor the weight of the mechanisms for the propagation and use of knowledge, but only of its production (Godin, 2006 [11]).

Indeed, a comparison between the definition produced by OECD of KBEs ("economies which are directly based on the production, distribution and use of knowledge and information") and the developed indicators shows a bias on the side of the mechanisms for the production of knowledge, measured by a direct approach that quantifies, through proxies, five categories, which should represent the KBEs or inputs, stocks and flows, networks and learning (Abramowitz and David, 1996 [1]; Foray and Lundvall, 1996 [8]); bias that is not substantially overcome even with the scoreboard of indicators presented in Nardo et al. (1999) [14].

More indirect is the approach of the World Bank, that, still through proxies (69 variables divided by categories), compares the performances of member countries within the five macro-analysis areas that should define the KBE:

1) overall performance of the economy;
2) economic incentive and institutional regime;
3) education and human resources;
4) innovation system; and
5) information infrastructure.

The same kind of definition of macro-categories, which represent, in an indirect way, the interconnections between production and dissemination of knowledge-use on the one hand, and the dynamics of socio-economic systems on the other, is also common to the Australian Bureau of Statistics' approach, whose effort to properly specify these indicators seems considerable: that reveals a purpose not to set the concept of KBE in brief synthetic frames, at all cost, but to represent all facets of the concept in a most accurate manner.

The EU project, Knowledge Economy Indicators (whose results are not yet available) is, in its premises, an example of how the concept of KBE is particularly fertile in terms of policy: the goal of the project is to identify indicators able to measure "drivers, characteristics, and key outputs" of a KBE "in order to boost EU competitiveness" and elaborate "policies needed in order to maximize its favorable impact".

The idea behind this work is that the difficulties to measure the KBE can be partly overcome if the analysis is conducted at the level of socio-economic local systems, in which some

World Academy of Science, Engineering and Technology
International Journal of Economics and Management Engineering
Vol:4, No:7, 2010

dimensions (such as social capital), which have no meaning at a national level, can be well defined and investigated. This allows to better combine the typical accuracy of statistical indicators with a wider representation and interpretation of what they quantify, by providing local decision makers with an analytical tool for understanding and impacting on socio-economic realities and their cognitive components.

III. THE LOCAL PERSPECTIVE

Recent developments in economic geography point at local contexts as more appropriate for the analysis of knowledge. In particular what is called the "learning region paradigm" is promising (Boekema et al. 2000 [5]; van Geenhuizen and Nijcamp 2002 [20]; Boekema 2003 [4]). This concept brings us to a reconsideration of what we have seen above about the existing definition and attempts to measure knowledge. The crucial point is how knowledge is created at the local level. The idea pointing at the presence of specialized institutions (such as universities, research centers and so on) in an area surfaces first. This idea should be widened in several direction. Firstly, one should not forget the possibility of knowledge being created by other agents like enterprises, families or individuals. Secondly, as pointed out by recent economic growth theories, knowledge can be created by knowledge itself. However, for this second effect to take place a third requirement is needed: the presence of interactions among the creator of knowledge. In fact one can think the knowledge creation process to be "combinatorial", that is, new ideas can be easily created combining concept from physics and economics, from medicine and engineering, from theory and practice, just to cite few examples. Under this point of view, an improvement in assessing knowledge comes from measuring the "connectivity" of the several networks linking the local actors and possibly monitoring the dynamics of this connectivity. The existing literature is working in this direction and mainly points on the number of cooperation between firms and universities (see Fritsch 2002 [9] for example). This investigation however, should be extended to take into account other networks as the cooperation among local firms in the same productive sector, these involving firms in different productive sectors, these among local and foreign enterprises, these among individuals of different nationalities and cultures.

Summing up to evaluate the level of knowledge one should take into account both static (number of universities, number of firms, size and age of enterprises (Laursen and Salter 2004 [12]), human capital and so on) and dynamic (number of cooperations among economic actors (Schmidt, 2005 [18]; Shapiro and Willig 1990 [19]) aspects.

Starting from the World Bank approach, in this paper we identify a large number of variables (belonging to 6 different topics) that in our opinion reflect the facets of the two aspects mentioned above at the local level.

IV. METHODOLOGY

To evaluate the performance of the services and activities offered by a socio-economic system, a widespread practice has become consolidated in the literature: that of using systems of indicators in order to conceptualize the phenomenon, through its size, thus making it possible both to monitor its evolution through space and time and to identify deficiencies, which show the need for intervention. However, the large diffusion of such tools in various fields of analysis (monitoring of economic and social policies, evaluation of performance of public services such as universities or health, etc.) has determined the proliferation of mismatched indicators, either because they do not exactly measure the same concept or because, although starting from a base of comparable data, they use different and not always statistically adequate methods of processing and aggregating these data. Furthermore an indicator should not be considered to have sense itself, but only as a term of comparison in case of measurements of different classes: the interesting point of an indicator is the understanding of the underlying situation. The use of statistical indicators has both advantages and disadvantages: they are useful because they can summarize many voices in a brief data and are handy tools for those who must take decisions; nonetheless, because of their extreme simplicity, they can easily be misinterpreted and lead to conclusions not entirely correct.

Finally, the identification of variables that can be objectively measured is extremely useful both to make a benchmarking of performance of two or more geographic areas or the same over time, and for a more immediate representation, for its simplification, of the complex dynamics that are often behind the data.

The process (both conceptual and operative), which has been led to correctly identify suitable indicators for the investigation field of this paper, has been carried out through three steps: the first entails the development of a theoretical framework, the second consists of a selection and an imputation of missing data, the third and last step is a process of reasoning about how to make a transformation of data in order to make them comparable. We analyze the steps in details:

1) the first step which led to the definition of the set of indicators was to define what is meant by knowledge, by making references to the work of various scholars and international organizations. This investigation on the concept of KBE has been the premise of the subsequent work of research and evaluation, leading to the selection and combination of individual indicators in a consistent and significant frame in accordance with the principle of fitness-for-purpose. By this way, six macro-areas analysis have been identified and, for each of these dimensions, some key issues have been singled out for which it was necessary to select suitable indicators.

2) The identification of the primary indicators and the imputation of missing data are two consecutive phases which stand at the core of the analysis. The selection of the indicators has been carried out on the basis of their analytical validity, of their measurability, of their spatial coverage, of their relationship with the other indicators and, in particular, of their importance for the phenomenon in hand. However, the first attempts of matching the variables selected in the first phase of the analysis and those actually available at a regional level have revealed gaps in local systems for statistical data

World Academy of Science, Engineering and Technology
International Journal of Economics and Management Engineering
Vol:4, No:7, 2010

collecting, and difficulties in obtaining data consistent from a temporal point of view. Precisely the inability to always give a measure to all of the indicators selected (for one or more Italian administrative regions and for one or more years) has led to the decision to separate the conceptual step of structuring the set of indicators from the operational phase of the measurement. That allows to pay more attention, in the future, to the process of data collecting (even in collaboration with one or more local or national statistical institutes), without having to "deform" the analytical framework depending on the presence or absence of the necessary data .

3) For this reason, the last step consists only in a simple exemplification of the measurement and benchmarking phase, carried on for some more representative variables, between the administrative region of Abruzzo and Italy as a whole, through standardization of data and construction of a radar chart.

V. STRUCTURE

Variables have been selected not in an attempt to directly measure the knowledge base of a local economy and the mechanisms which link this to the growth of the system. In contrast, variables are large in number and varied in type, just because this approach seeks to indirectly represent the multiple, multidimensional and often bidirectional relationship between socio-economic local systems and knowledge dynamics. That is, because of the impossibility to exactly measure the immaterial, cognitive inputs of an economic reality, and then to put them in a precise relationship with the outputs of the economic process (according to a well known production function), it has been conducted a screening of all the features of a society which may shed light on how the relationship between knowledge and economics takes shape. Therefore, a wide range of socio-economic aspects which could be quantified and measured by any indicator has been taken into account; then each indicator has been interpreted in a positive or negative manner, depending on whether it reveals the presence of a factor which, either directly or indirectly, facilitates or hinders the realization of virtuous circuits of diffusion-production-use of knowledge.

The process has led to the identification of six main dimensions:

A - overall performance of the economy;
B - the economic and institutional regime;
C - innovation system;
D - education;
E - information and communication technology;
F - culture and social capital.

Finally, each indicator is described in the context of the dimension and characteristic for which it is intended to be a measure. For each of these six dimensions a sub-set of indicators has been identified, for a total amount of 54 variables. The sets of variables are reported in tables I-VI.

VI. A SYNTHETIC REPRESENTATION

To be fully informative, such a high number of variables has to be accompanied with synthetic values. We are in favor of

TABLE I
A - OVERALL PERFORMANCE OF THE ECONOMY

	Macro variable	Description
A1	GDP per capita	
A2	HDI	It is measured through: life expectancy index of education index of GDP
A3	Index of inequality	
A4	Competitiveness	It is measured through some indicators of infrastructure.
A5	Available income per capita	
A6	Suffering banking customers use than ordinary	
A7	Exports in goods and services	
A8	Imports in goods and services	

TABLE II
B - THE ECONOMIC AND INSTITUTIONAL REGIME

	Macro variable	Description
B1	Bankruptcy of enterprises	It measures the local competitiveness
B2	Companies registered per inhabitant	
B3	Enterprise discontinued per capita	
B4	Relationship between the number of employees and the total of firms	
B5	Number of firms in a given field k than the national average for the respective field	
B6	Cost to register a business	
B7	Number of days required to start a business	
B8	Gross credit to the private sector	
B9	Exchange rate between banks	
B10	Role of Law	It is measured through: average time of a process number of crimes
B11	Offenses against public administration	
B12	Taxation	

a progressive aggregation process where the original variables are gradually merged into higher level indicators. However, although it could be useful to bring this process at the highest possible level (so that to arrive at a sole figure summarizing all the original variables), we will not reach this final step here. In our opinion, stopping the six macro variables allows us to have a global picture while avoiding to lose too much information.

Before presenting this halfway synthetic representation, we want to point out, that our effort in identifying the original variables should be taken as an advise to local policy making

World Academy of Science, Engineering and Technology
International Journal of Economics and Management Engineering
Vol:4, No:7, 2010

TABLE III
C - INNOVATION SYSTEM

	Macro variable	Description
C1	Foreign direct investment	
C2	Domestic direct investment	
C3	Number of subscribers to the science on the total number of subscribers	
C4	Employees in R & D	It is measured through the employees in public institutions in private non-profit institutions in business in universities
C5	Spending on research and development	
C6	Number of employees in basic research	
C7	Collaborations between research institutions and the business world	
C8	Number of technical scientific journals	
C9	Patents	As inventions, designs, trademarks and utility models
C10	Patents	Number of patent applications
C11	Export in high tech	
C12	Number of innovative enterprises	Divided between companies that have only innovation of product, only process and product and process
C13	Internet and business	Measuring the diffusion and use of Internet related services
C14	Broadband	Degree of diffusion of broadband in local government

TABLE IV
D - EDUCATION

	Macro variable	Description
D1	Schooling	
D2	Internet access in schools	
D3	Regional spending on education	
D4	Training	Participation in training courses and number of active
D5	Spread of foreign language	
D6	Number of businesses in education	
D7	Educational qualifications for employment	
D8	Investment in training per capita	
D9	Contents of envelope structures for education	

TABLE V
E - INFORMATION AND COMMUNICATION TECHNOLOGY

	Macro variable	Description
E1	Degree of spread of the Internet in households	
E2	Allocation of personal computers	
E3	Dissemination Service of e-government	
E4	ICT	Spending in ICT

TABLE VI
F - CULTURE AND SOCIAL CAPITAL

	Macro variable	Description
F1	Number of people involved in volunteering	
F2	Contents of envelope structures for culture	
F3	Number of non-school books products	
F4	Investing in culture	
F5	Number of companies operating in the field of culture	
F6	Participation in community activities	
F7	Working days lost to strike	

to orient their information system in such a way that it could collect these data where they are not yet recorded. This statement stems from the difficulties we encounter in gathering the data for the identified variables.

To provide a simple example of what could be considered the outcome of our work, we select one variable for each of the six categories both at the local (for the Abruzzo Italian region) and at the country level. We normalize and arrange them in the radar graph presented in next figure. It is straightforward from the visual inspection that the main difficulties of the considered local area are represented by a weak innovation system and by a low level of culture an social capital.

VII. CONCLUSIONS

Following the relevance assumed by the concept of human capital in explaining economic phenomena, economists are trying to generalize the concept. The result of this process is the notion of knowledge. As one can imagine, this wide concept presents several difficulties to be handled starting from its definition. A second topic is the measurement of knowledge.
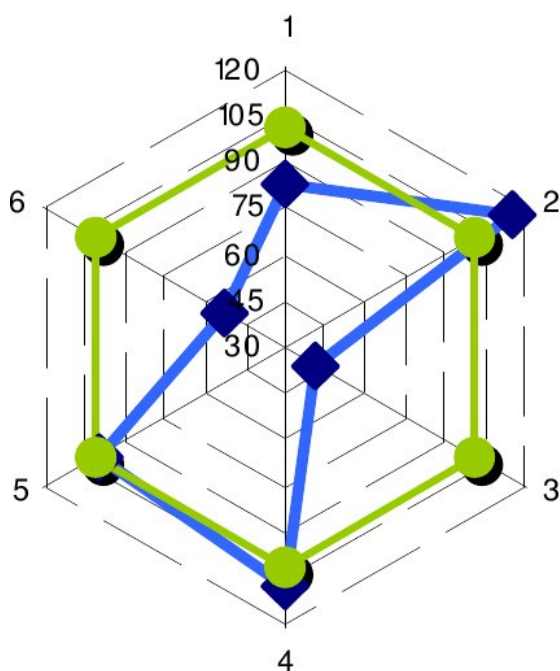
World Academy of Science, Engineering and Technology
International Journal of Economics and Management Engineering
Vol:4, No:7, 2010

Fig. 1. The six dimensions for Italy (bullets) and Abruzzo (diamonds).

TABLE VII
VARIABLES REPRESENTED IN THE RADAR GRAPH.

	Explanatory variable	Abruzzo 2007	Italy 2007
1	GDP per capita	81.88	100
2	Active companies	114.42	100
3	Number of inventions in the population	41.36	100
4	Total employment in possession of technical colleges, or doctorate degree with respect to total employment	106.25	100
5	Degree of spread of the Internet (access) in families	98.73	100
6	Contents of envelope structures for culture	51.71	100

In this paper we aim to smooth these difficulties out by taking a local perspective. At a local level, knowledge is fostered by the existence of both formal and informal institutions aiming at producing knowledge. However and perhaps most importantly, knowledge consists in the ability of the area to exchange information being opened to new experiences and cultural exchanges. In other words, knowledge in a dynamic sense is represented by the vitality of the social networks connecting economic agents.

With respect to measuring, we follow the World Bank approach and we identify a large number of socio-economic variable belonging to six macro areas. These variables provide a detailed picture of the knowledge -based relations which occur in a local socio-economic context, underpinning its dynamic efficiency and social welfare. This further step: we give a preliminary insight on this point by giving a joint representation of the six macro variables we identified by means of a radar graph comparing a regional and a national context.

REFERENCES

[1] Abramowitz M. and David P. (1996), Technological change and the rise of intangible investments: the US economy's growth path in the twentieth century, Employment and Growth in the Knowledge-based Economy, OECD, Paris.
[2] Australian Bureau of Statistics (2002), "Measuring a Knowledge-based Economy and Society, An Australian Framework (Discussion Paper)".
[3] Blackler F., (1995): "Knowledge, Knowledge work and organization: an overview and interpretation", Organization Studies, Vol. 16, No. 6, pp. 1021-1046.
[4] Boekema F.(editor) (2003), "Economic Geography of Higher Education: Knowledge, Infrastructure and Learning Regions", Routledge Studies in Business Organization and Network.
[5] Boekema F., K. Morgan, S. Bakkers, R. Rutt (Editors) (2000), Knowledge, Innovation and Economic Growth: The Theory and Practice of Learning Regions. Edward Elgar.
[6] Cooke P. and Leydesdorff L. (2006), "Regional development in the knowledge-based economy: the construction of advantge", The Journal of Technology Transfer, Springer, vol. 31(1), pp. 5-15.
[7] Foray D., "L'economia della conoscenza", Il Mulino, 2006.
[8] Foray D. and Lundvall B. A. (eds.) (1996), Employment and growth in the knowledge-based economy, Paris: OECD
[9] Fritsch (2002), "Does R&D-Co-operation Behaviour Differ between Regions?", Working Paper - Faculty of Economics and Business Administration, Technical University of Freiberg, Freiberg, January
[10] Gille L. (2005), "La protezione della proprietà intellettuale, fattore della divisione internazionale della conoscenza", in Pilati A. and Perrucci A. (edited by), Economia della conoscenza, Il Mulino.
[11] Godin B. (2006), "The knowledge-based economy: conceptual framework of buzzword?", Journal of Technology Transfer, n. 31, pp. 17-30.
[12] Laursen, K. and A. Salter (2004), "Searching High and Low: What Types of Firms Use Universities as a Source of Innovation?", Research Policy, 33, 1201-1215.
[13] Leydesdorff L. (2005), "Anticipatory systems and the processing of meaning: a simulation study inspired by Luhmann's theory of social systems", Journal of Artificial Societies and Social Simulation, vol. 8.
[14] Nardo M., Saisana M., Saltelli A, (2005) "Handbook on constructing composite indicators: methodology user guide", OECD Statistics Working Paper.
[15] Noam E. (2005), "L'impatto economico della conoscenza sull'impresa", in Pilati A. and Perrucci A. (edited by), Economia della conoscenza, Il Mulino, 2005.
[16] Pilati A. and Perrucci A. (editors) (2005), Economia della conoscenza, Il Mulino.
[17] Rullani E, "Economia della conoscenza. Creatività e valore nel capitalismo delle reti", Carocci, 2002
[18] Schmidt, T. (2005), "Knowledge Flows and R&D Co-operations: Firm-level Evidence from Germany", ZEW Discussion Paper No. 05-22, Mannheim.
[19] Shapiro, C. and R. Willig (1990), "On the Antitrust Treatment of Production Joint Ventures", Journal of Economic Perspectives, 4, 113-130.
[20] Van Geenhuizen M. and P. Nijcamp (2002), "Lessons from learning regions: policymaking in an evolutionary context". Research memorandum 2002-34 Faculty of economics and business administration, university of Amsterdam .
[21] Volle M. (2005), "Economia della conoscenza ed economia delle reti di comunicazione", in Pilati A. and Perrucci A. (edited by), Economia della conoscenza, Il Mulino.