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A Conceptual Framework for the Study of Research Ecosystems

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Abstract: The concept of ecosystems serves as a powerful metaphor in organizational studies that helps to handle the complexity of the environment in contemporary organizations and steps forward the movement towards symbiotic and co-evolutionary organizational networks. This paper elaborates on the concept of ecosystems to propose a conceptual framework for research ecosystems. The proposed concept of research ecosystems can offer significant benefits for the coordination of research initiatives because it clarifies the attributes of the research environments, outlines the general context in which research activities take place and supports the movement from the contextual level to the particular projects' level. The paper delineates also two methods for the study of research ecosystems that refer to the assessment of the density of relationships in research ecosystems and the development of research networks as temporary constellations of research entities.

Keywords: ecosystem, research network, European Research Area (ERA), research project management, social network analysis

1. Introduction

The European Union (EU) set the very ambitious goal to become by 2010 the most competitive and dynamic knowledge-based economy in the world (Lisbon Strategy [1]). Core elements of the Lisbon Strategy are the accomplishment of a common research policy and the development of a pan-european research and innovation structure, equivalent to the traditional "common market" for goods and ser-vices, which was called the "European Research Area" (ERA) and aimed at the improved coordination of research activities and the convergence of research and innovation policies at EU and national level [1].

The excessive complexity in the direction and coordination of research and innovation projects, programmes and policies can be relieved by the development of new approaches and methods in their management. Accordingly, Gummesson [2] advocates that inputs from natural sciences, systems' theory and network theory, which cope with dynamic and complex phenomena, are useful in the research of management and business studies.

Based on the description of the ERA as "an internal market for research" and as a coordinative mechanism of research activities, programmes and policies in Europe [1], this paper elaborates on the concept of ecosystems to propose a conceptual framework for research ecosystems. Built on concepts and insights from biological systems and complexity theory [3, p. 9-10], the concept of ecosystems serves as a powerful metaphor in organizational studies that helps to handle the complexity of the environment in contemporary organizations and steps forward the movement towards symbiotic and co-evolutionary organizational networks. A business ecosystem, for example, is defined as "an economic community comprised of a number of interacting organizations and individuals, including suppliers, producers, competitors, customers and other stakeholders, that produces goods and services” [3, p.26].

The proposed conceptualisation of research ecosystems offers significant benefits for the management of research policies and the coordination of research programmes. First of all, it emphasizes the attributes of research environments as dynamic, complex, synergetic and symbiotic areas; research policies should take into account these attributes and try to elaborate on them (e.g. to promote but also regulate competition among research contributors; to create centrepiece RTD infrastructures as keystone entities for the development of research activities, etc.). In addition, the proposed concept of research ecosystems outlines the general context in which research activities take place. It encompasses all the actors that participate in research activities, as well as other stakeholders that can be interested in the research activities. In such an environment, certain research activities are dynamically developed and organised in research projects, which are conceived as temporary constellations of entities of the research ecosystem. The ecosystem approach, hence, offers a unifying mechanism for the movement from the contextual to the specific level of research activities, or from the level of research policies to the level of research projects and their implementation. This way it can support the coordination, the analysis and the synthesis of research policies, activities and outcomes. Besides, it can be used for the investigation of alternative or improved solutions in the organization and implementation of research activities, serving to the evolution and recycle of the research environment

The structure of the paper is as follows: in section 2 we describe briefly the background and the objectives of the work. In section 3 and 4 we provide the detailed description of the methodology for the conceptualisation of research ecosystems and we delineate two approaches for analyzing research ecosystems which refer to the development of research projects within research ecosystems and the assessment of the density of research ecosystems respectively. The paper concludes with the presentation of results and directions for future work.

2. Objectives

The examination of the extent to which innovation and research project serve the needs of the society is very crucial. Public support for RTD projects has been justified in the economics literature on the basis of market failures and system failures [5]. However, due to the knowledge-intensive and intangible character of the inputs, processes and outputs in RTD projects, there is a general inadequacy in ways that they can be evaluated [5]. It is advocated that the traditional approaches, such as accounting for inputs and outputs and/or outcomes, leave relatively untouched the dynamics of RTD and innovation, i.e., the processes involved in generating innovation outcomes that are non-linear, networked and with multiple feedback loops.

Similar analyses that focus on the structure of RTD and innovation-related networks have been published in recent years [5, 6, 7]. All these efforts share some common objectives and apply a common core methodology, which is based mainly on social network analysis. In addition, they all addressed the network characteristics of research consortia and the behavioural implications of EU-funded IST-RTD and deployment projects in terms of competencies, capabilities, organizational structures and strategies of their respective participant organizations. However these efforts apparently fell short in inquiring about the impact of such networks on the diffusion of innovation processes and novel technologies at the EU, national and regional levels. The study on research ecosystems was initiated as an extension of research performed in the SMART project [4].

The main objective of the framework is to assess how effectively IST-related RTD and deployment initiatives are being exploited in systems of innovation at the EU Member State and regional levels. Thus, the main focus of the research is to map, display and analyse the various networks of collaboration generated and supported by different types of IST-related RTD and deployment projects and programs, as well as to assess their impact by measuring the capacity to innovate and assimilate innovation at regional level.

A second important objective is to examine the extent to which innovation and research project serve the needs of society as it is shown that public support for RTD projects has been justified in economics literature on the basis of market failures and system failures [5].

Subsequent objectives are:

- The identification of different roles and actors in a research eCosystem
- The identification of the enabling attributes
- Developing Research Networks in Research Ecosystems and the
- Assessment of the density of the relationships in Research Ecosystems

3. Methodology Used for the Conceptualisation of Research eCosystems

In this section we provide the methodology for the conceptualisation framework of research ecosystems and describe the functions and key attributes of research ecosystems. The conceptual framework is based on the “European Research Area” (ERA), which was initiated as a pan-european research and innovation structure, as “an internal market” for research activities [1]. Such a structure encompasses all the actors that are involved in research and innovation initiatives supported by the EU and aims at their coordination and direction. For this, we consider that the ERA is an appropriate background for the development of a conceptual framework on research ecosystems.

3.1 Roles and Actors in Research Ecosystems

The ERA encompasses multiple types of actors that may perform various roles [1, 8, 9]. Key entities that are involved in the ERA are the following:

Research organizations, such as universities and research institutes. Being the major producers of research outputs, they play a key role in the RTD process.

Individual researchers, such as experienced researchers and students at postgraduate or undergraduate level, not only work for research organization, but they are also eligible for direct participation in RTD projects.

Business enterprises, including industrial, commercial and other types of business firms, participate usually as beneficiaries in RTD projects; sometimes they tend to be the key performers, such as in research deployment projects.

Public administrations, similarly to business enterprises, participate usually as beneficiaries in RTD projects, while they may undertake more active role in certain research processes.

Political and administrative authorities (e.g., EU’s various institutions, advisory bodies, governments, ministries, specialised public institutes, etc.),

Funding organizations include both public funds operating at European, national and regional level,

Intermediaries and support organizations include a variety of consultancy organizations and other technology or business experts.

Support infrastructures, built at European, national and regional level,

Research bodies and associations, such as scientific associations, standards organizations, standardization organizations, think tanks, patent organizations, etc

Repositories of scientific knowledge, such as libraries, scientific databases and organizations for the dissemination of research and technology outputs, facilitate the dissemination of scientific knowledge.

Organizations of the civil society, such as civil associations and pressure groups.

Customers, consumers and professional users,

Research organizations, firms, authorities and persons from third countries that are invited in EU research projects, because nowadays RTD takes place in the global arena for research excellence.

Figure 1 portrays a research ecosystem based on the participants in the ERA. The relationship between two entities is indicated with an arrow pointing at the entity that receives support or input or is affected in general (not all relationships are shown in the figure to avoid unnecessary perplexity). For example, Repositories of Knowledge, Research Intermediaries and Political and Administrative Authorities (e.g. EU's science and research authorities) support Research Organizations; Research Organizations cooperate with Business Firms and Public Administrations in research project by receiving inputs for research and delivering the research outcomes to them.

Research Organizations hold a central role in research ecosystems, but they do not act as hubs necessarily. The entities can be connected directly with each other, according to their purposes and interests. For example, Business Firms may associate directly with Third Country Research Organizations, Individual Researchers, Research Intermediaries and Customers. From this point of view, even though the proposed research ecosystem is based on the concept of the ERA, it is not restricted to research initiatives that are developed under the auspices of EU, but may encompass also research activities initiated, for instance, by business firms and funded exclusively with private funds.

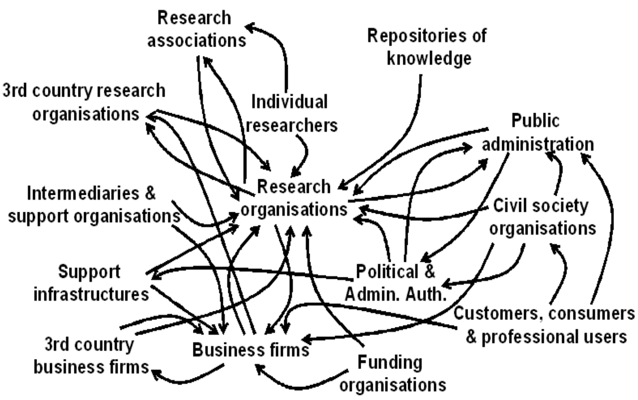

Figure 1: Flora and Fauna in Research Ecosystems

Research projects are formed as temporary constellations of a variety of entities in research ecosystems, according to the needs and the purposes of the project.

3.2 Attributes of Research Ecosystems

The research environment is evolutionary in nature, as new scientific and research output are produced everyday and are incorporated in current field of knowledge, affecting it and sometimes changing it dramatically. The research environment is extremely volatile and there is need for continuous adaptation to the new knowledge and technologies.

Research is usually multidisciplinary and participation transcends research fields and business sectors. The new input from different fields and diverse contributors fertilizes the research field, improves the research process and enriches the research outcomes. The role of the keystone entities is well documented in the literature of natural and business ecosystems [e.g. 11]. In research ecosystems keystone entities can be either entities that play a coordinative role in research activities (e.g. EU's science and research institutions at macro level and research coordinators at project's level) or entities that support significantly the evolution of the research process (e.g. key research infrastructures, such as the European Institute of Technology or the GEANT, standards organizations, etc.). In this prospect, the European Technology Platforms and the ERA-Nets [1] can be thought as keystone entities for the development of research in certain technological fields and geographic regions respectively.

Interdependence is an intrinsic attribute in research projects. Most research activities today involve a great array of assets, capabilities and inputs, which no one single organization –either research institution or business firm– usually possesses or can deploy at reasonable cost by its own. For this reason, RTD projects are organized as cooperative networks, in which various actors participate by contributing certain core competencies and engaging in extensive cooperation with the other partners. Collaboration exists in research networks when two or more partners cooperate to produce a common objective or a mutual benefit

4. Employment of Methods and Approach

In this section we describe the two methods employed for the study of research ecosystems that refer to the development of research networks and the assessment of the density of relationships in research ecosystems.

4.1 Developing Research Networks in Research Ecosystems

The proposed approach supports the early stages of formation of research networks within research ecosystems, such as the determination of the purpose and objectives of the project, the creation of the research network and the development of exploitation strategies both at project level and at members' level. The approach is based on the assumption that research projects are formed as temporary constellations of a variety of entities in research ecosystems, according to the needs and purposes of the project and the influence of the participants. It is also assumed that, even if the partners collaborate for the achievement of the general project's goals, which are common, they pursue their individual goals and proprietary benefits at the same time.

The proposed approach is depicted in fig. 3. It is based on PACE Exploitation Toolkit [12] used for research projects management, which builds on an adapted version of the "Weightless Wealth Toolkit" [13, 14], used for measurement of intangible assets.

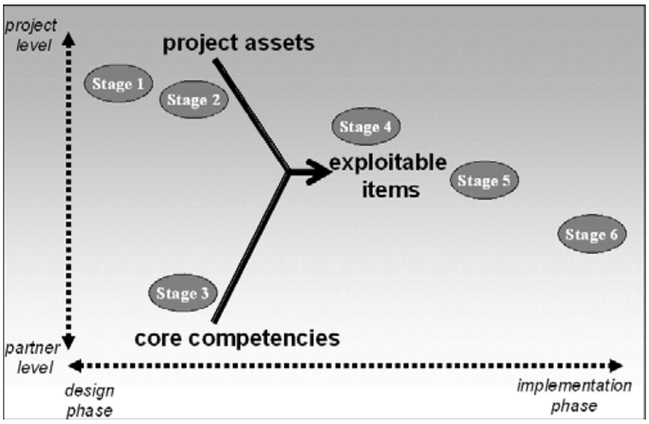

Figure 2: Developing Research Networks In Research Ecosystems

The approach is developed in 6 stages:

Stage 1. Definition of project's purpose. The initial stage begins by a small group of entities that have a research idea. It refers to the definition of the project's purpose, the determination of the main outcomes, the core methodology, etc. The analysis is performed at project level. At the end of this stage, the participants can obtain a common view of the project's whereabouts.

Stage 2. Definition of project's assets. At this stage the participants needs to map and agree on the project's assets, which relate to specific deliverables or any other type of results, synergies and achievements that are being created during the project. Assets can be both tangible and intangible (e.g. including from patents to software, prototypes or methodologies).

Assets can be collectively owned by all partners or partly owned by one or some partners. Even though an agreement on the ownership of the assets sustains rivalry, it also makes obvious the synergies and encourages the identification of opportunities for collaboration, when an asset is owned by more than one partner.

Both phases 1 and 2 describe the background of the project and provide the preconditions for the decision on participating in a research consortium. Other necessary input for this decision is provided in stages 3 and 4, which refer to partners' contribution in the project and their expected benefits respectively.

Stage 3. Identification of core competencies. The third stage refers to the identification of each partner's core competencies with respect to the project, including both these that are contributed to the project and those that are affected by the project. Contributed core competencies reveal how useful and well-fit each partner can be in the project; affected core competencies reveal the expected benefit.

Stage 4. Connection of project assets with core competencies: recognizing "exploitable *items*". The concept of the exploitable items is the bridge between the project's assets and the partners' core competencies. This concept is very important for the success of the project and the satisfaction of the partners. At project level, it reveals if the partner's core competencies are well-fit with the project requirements and promise to achieve the project outcomes. At members' level, it forms the basis for the internalization of the project's outcomes, which is a fundamental criterion for participation in a project.

Stage 5. Development of exploitation strategies. In this stage the consortium develops strategies for the development of the exploitable items. Each partner may also develop strategies for the internalization of the project's outcomes. The strategies can be ad hoc, because the exploitation of RTD outputs has to be innovative. Koumpis and Mavridis [12] provide generic categories of exploitation strategies.

Stage 6. Development of strategy exploitation roadmaps. At the final stage, the exploitation strategies are further developed into exploitation roadmaps. This stage offers further opportunities for research collaboration with others, both inside and outside of the consortium, because it can reveal the required synergies for the successful implementation of the exploitation strategies.

4.2 Assessing the Density of Relationships in Research Ecosystems

It is important to have mechanisms that support the description and assessment of research ecosystems and research networks that are developed within. With this aim, we applied social network analysis for the assessment of the research networks in the FP6. We adopted a bottom-up approach, according to which we tried to map the FP6 research ecosystem by processing the data of its projects and analyzing the relationships among the participants. Notice that this approach cannot reveal the complete research ecosystem, such as the one depicted in fig. 1, because the available data refer to eligible for funding only participants in FP6 research projects. In detail, we processed a sample of 179 RTD projects in the FP6 and registered 4,861 participating organizations.

Social network analysis [15, 16, 17] provides a rich methodological framework for the study of research networks. It can be used, for example, to estimate how well on average each organization is connected to the others, how dense is the network and how close on average is one partner to another.

Instead of producing graphs, which can become very complex and sometimes poor in communicating useful information, we established a database that processes FP6 data (accessible at http://212.89.165.216/smart). According to this approach, outputs are presented in tabular form, which is more straightforward for analysis. We produced two basic types of outputs: the first refers to the structure and density of each particular research entity's ecosystem and the second refers to the potential associations in the FP6 research ecosystem.

The structure and density of a particular research entity's ecosystem is based on the actual partnerships of this entity in the FP6. The results are organized in two dimensions: the rows refer to spatial origins of partnering research entities (at Regional, National, European and International level) and the columns refer to the type of partnering research entities (i.e. Business Enterprises (ENT), Research Centres (REC), higher education institutions (HEI) and Public Administrations (GOV) and Other Types (OTH)). An example of this analysis is given in table 1. We see that a research entity has collaborated directly with 282 organizations and these partnerships are distributed as shown in Table 1.

Table 1 Particular Research Entity Ecosystem

282 Partnerships	ENT	REC	HEI	GOV	OTH
Regional	2	1	2	1	0
National	0	3	3	1	0
European	40	27	102	30	37
International	6	8	13	2	4

From an ecosystem's point of view, it is extremely useful to know the associates of our research partners (i.e. "the partners of our partners"). In a general setting, it is important because partnerships are usually based on the existence of common attributes between organizations, such as values, mind-set, attitudes, objectives, etc. By knowing the associates of our partners, we expand significantly the pool of the potential partners and multiply the opportunities to develop new partnerships. In reality, such information becomes more valuable if we manage to rate in advance the quality of partnership with our partners and filter the results accordingly, to receive the associates of our "best partners".

Table 2 presents the outcomes for the same research entity. It is clear that knowing the associates of our partners propagates the number of possible associations and fosters the development of new partnerships. Notice that the analysis of the potential associations emphasizes the role of proximity and social ties in the process of creating research networks and supports, therefore, the concept of developing research networks in research ecosystems, as was advocated in section 3.

Table 2: Potential Associations in the FP6 Research Ecosystem

3,627 Associations	ENT	REC	HEI	GOV	OTH
Regional	5	3	4	1	0
National	33	8	19	2	46
European	1107	292	390	96	1096
International	163	67	123	25	148

5. Results and Benefits

5.1 Selection of Regions for Analysis

In order to study our proposed framework through the networks created by EU Framework Programmes and to understand their impact on regional systems of innovation, 10 regions were selected for in-depth analysis. Our selection methodology started from the NUTS 2 level of the EU-25 that was composed of 254 regions but excluding capital regions. The latter usually have already been studied and are special cases with a large concentration of industrial actors, universities and national research centres. Instead, we elected to focus on non-capital 'core' and 'peripheral' regions. We identified 'core' regions as those with a population greater than 400,000 people to ensure a critical mass of industrial, RTD and innovation activity. At the same time we restricted our attention to NUTS 2 regions with a population density lower than 1,000 people per square kilometre.

These conditions were met by 196 non-capital 'core' regions.

The next step was to categorize this list of regions in terms of their performance on basic macro-economic indicators, choosing GDP, Public sector RTD investment and Enterprise RTD investment as a set of three independent parameters upon which to base our categorisation. For each of these we defined Low, Medium and High performance. This approach led us to propose the following five pairs of regions for closer study:

Table 3: Choice of Regions for the Analysis

Pairing No.	Regions	FP6 Participations
1.	De91 – Braunschweig (Germany) Ukj4 – Kent (UK)	54 3
2.	Gr43 – Crete (Greece) Se09 – Smaaland (Sweden)	64 8
3.	Be24 – Flanders (Belgium) Fr72 – Auvergne (France)	177 7
4.	Cz06 – Jihovýchod (Czech Republic) Itc3 – Liguria (Italy)	14 3
5.	Es21 – Pais Vasco (Spain) Pl61 – Kujawsko-Pomorskie (Poland)	97 3

The above pairings were considered relevant because:

- The regions have roughly similar macro-economic characteristics from the point of view of the categorisation parameters selected, i.e. per capita GDP, Public sector RTD investment and Enterprise RTD investment;
- They differ in their level of participation in the Framework Programmes, typically belonging to the 'top' and the 'bottom' performers in each identified cluster, from the point of view of the number of participations.

We prepared Intellectual Capital profiles of the 10 regions and analysed the similarities and differences within each of the 5 pairings and with respect to the Israel benchmark. This allowed us to analyze the 10 selected regions in terms of innovation performance and Intellectual Capital and gain insights into their innovation dynamics and their potential for future growth.

5.2 Findings

Employing our framework for the selected regions we identified the following findings, which we summarise below:

What is happening in the ICT Framework Programmes according to our evaluation is that organisations in more developed regions such as those with capital cities have been better able to participate in more ICT RTD projects. But the impact of participation on local productivity and competitiveness has been stronger in the less developed regions of Europe. Those are also the regions that are benefiting the most from Structural Funds expenditure, so we should be careful in establishing this as an exclusive or prevalent effect of EU research policy. Moreover, development theory holds that economies with lower starting conditions typically grow more than the more affluent ones.

1. EU-funded ICT RTD and deployment programmes have a clear and positive impact on the Intellectual Capital of regions
2. The regional innovation capacity is positively correlated with participation in the EU Framework Programmes
3. The innovation diffusion process triggered by EU-funded ICT RTD and deployment programmes enhances convergence between the regional economies of the Union.
4. Organisations as recipients of both tangible and intangible assets – created through participation in ICT RTD and deployment programmes – redistribute these assets locally to other organisations through expansion of their collaboration networks.
5. The goals of the EU Framework Programmes, to create and support industry-science linkages and to reduce the structural barriers to the development of innovative projects across borders and sectors in Europe, have been more effectively pursued at national than at regional levels.
6. Regions with the strongest participation in ICT RTD and that show the highest growth of innovation propensity also exhibit the best performance in terms of presence of knowledge workers in medium-to-high-tech manufacturing and in high-tech services.
7. The capacity of a regional system to absorb innovation and convert it into economic growth depends on a combination of structural and socio-cultural factors
8. While FP6 projects clearly improve the density and cohesion of interregional networks, this is not the case for intraregional networks.
9. Some organisations that are hubs in interregional consortia do not appear to be connected at the intraregional level, thus calling into question their effectiveness in disseminating innovation within the region.
10. Regional awareness is essential to enhance collaboration and networks through ICT RTD participation.

6. Conclusions

The paper presents a conceptual framework for the study of research ecosystems. Based on the needs and circumstances of the European Research Area (ERA), the proposed concept of research ecosystems outlines the general organisational context for the development of research initiatives and supports the development of research strategies, the coordination at macro level of research programmes and activities and the development of new research partnerships. The paper presents also two fundamental methods for the development of research networks in research ecosystems and the assessment of the density of relationships in research ecosystems.

Insights from natural ecosystems and social networks analysis are important for the mapping and analysis of research ecosystems. Future work should focus on the in-depth study of research ecosystems and the development of a thorough methodological framework for the analysis of research ecosystems.

References

[1] European Commission, Green Paper on The European Research Area: New Perspectives, COM (2007) 161 final, April 2007.

[2] E. Gummesson, “Qualitative research in management: addressing complexity, context and persona”, Management Decision, 2006, Vol. 44, No 2, pp. 167-179.
[3] J.F. Moore, The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems, J. Wiley & Sons, Winchester, England, 1996.
[4] European Commission, Tender specifications on the “Effectiveness of IST-RTD impacts on the EU Innovation system, SMART: 2006/0019, 2006. Available at: www.smart-research.eu
[5] CESPRI, Evaluation of progress towards a European Research Area for Information Society Technologies, Final Report submitted to the European Commission, Directorate-General Information Society and Media, Unit 3C – January, 2006.
[6] CESPRI, Networks of Innovation in Information Society: Development and Deployment in Europe, Final Report submitted to the European Commission, Directorate-General Information Society and Media, Unit 3C – December, 2006
[7] Rand Europe, ERAnets – Evaluation of Networks of Collaboration among Participants in IST Research and their Evolution to Collaborations in the European Research Area (ERA), Report prepared for the European Commission Directorate-General Information Society - 31 March 2005.
[8] European Commission, Participating in European Research: Guide for applicants under the Sixth Framework Programme for European Research & Technological Development (2002-2006), 2nd ed., 2004.
[9] European Commission, The future of Key research actors in the European research area: Synthesis Report, 2007.
[10] E. Von Hippel, Democratizing Innovation, Cambridge, MA, MIT Press, 2005.
[11] M. Iansiti and R. Levien, The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation and Sustainability, Harvard Business School Press, Boston Massachusetts, 2004.
[12] A. Koumpis & A. Mavridis, “The PACE Exploitation toolkit”, eChallenges e-2006, Published in: “Exploiting the Knowledge Economy: Issues, Applications, Case Studies”, Paul Cunningham and Miriam Cunningham (Eds), IOS Press, 2006 Amsterdam, ISBN: 1-58603-682-3.
[13] D. Andriessen, “IC Valuation & Measurement: Why and how?”, PMA IC Research Symposium, October 1st-3rd, 2003, Cranfield School of Management.
[14] D. Andriessen, Making Sense of Intellectual Capital: Designing a Method for the Valuation of Intangibles, Butterworth – Heinemann, Oxford, UK, 2004.
[15] S. Wasserman, & K. Faust, Social network analysis, Cambridge: Cambridge University Press, 1995.
[16] J. Scott, “Social Network Analysis”, Sociology, 1988, Vol. 22, No. 1, 109-127
[17] E. Otte and R. Rousseau, “Social network analysis: a powerful strategy, also for the information sciences”, Journal of Information Science, 2002, Vol. 28, No. 6, 441-453.