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An Integrated Scheme for the Evaluation of Institutional Set-Ups: The Case of the Belgian Regional Innovation System

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Abstract

The success of an effective Science, Technology and Innovation (STI) policy depends not only on the relevant combination between the STI objectives and their related instruments but also depends to a large extent on the interactions between public and private institutions whose activities deal with innovation. Yet, it is now widely recognised that significant institutional mismatches coexist with market failures. In that matter, this paper aims at presenting an original framework for the empirical assessment of innovation systems from an institutional perspective by suggesting a classification method of the institutional set-ups of innovation systems. The analytical framework is based upon the four following criteria: *international comparability* of results; *representativeness of results* with regard to the institutional profiles of countries; *measurement issues* of the institutional mapping; and *consistency* of the approach with regard to the concept of institutions. Concretely, the methodological framework relies upon the construction of the institutional STI mapping which is obtained by crossing identified STI objectives, STI instruments and innovation institutional actors into four *functional matrices* that should all together empirically describe the innovation process that may occur at different spatial levels. The stress will be put upon the Belgian case study mainly because its federal political configuration makes it comparable to some extent to the European Union institutional structure.

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1. Introduction

For decades, there has been a growing consensus on the necessity to deepen our understanding of the innovation process and its link with the Science, Technology and Innovation (STI) governance. Innovation performance is not only the result of quantitative inputs but also depends to a large extent on the interactions between public and private institutions whose activities deal with innovation. Though, it is now widely recognised that significant institutional mismatches coexist with market failures. In that matter, evaluation of STI public initiatives is becoming a key decision support tool that provides policy makers with a better understanding of policy results, allows learning from past and external experiences, provides elements for improving strategy definition, increases the efficiency and effectiveness of policy intervention, and demonstrates the effects of intervention. Yet, Nelson (1993) emphasises "the absence of a well-articulated and verified analytical framework linking institutional arrangements to technological and economic performance". If it is now obvious that institutions matter a lot in innovation systems, it is of great concern for governments (either local or national) to have a clear view on their innovation governance.

Within this view, the objective of this paper is to present an innovative framework for the assessment of innovation systems from an institutional perspective by suggesting a classification method of the institutional set-ups of innovation systems. Concretely, the methodological framework suggested relies upon the building of the institutional STI mapping which is obtained by crossing identified STI objectives, STI instruments and innovation institutional actors into four *functional matrices* that should all together empirically depict the innovation process that may occur at different spatial levels.

The paper is organised as follows. In order to provide the theoretical background, we first review the existing literature on Innovation Systems (IS) given its spatial issues. Then, in section two, a taxonomy of the main components of Innovation Systems is proposed given the following statement: Innovation is a complex system of interactions between different *institutions* aimed to fulfil some specific *objectives* through the efficient implementation of *instruments* which might be politically implemented at different spatial levels. In the fourth section, we explain the operational methodology implemented as well as its strengths and weaknesses. Finally, we analyse the results represented by the Belgian regional functional matrices. The Belgian institutional peculiarity lies on its federated structure which is a sum of national, regional and local systems each with their own political competences[2]. The seven Belgian federated entities with their seven governments might be viewed as an experimental lab to study in a further extent the European Innovation System.

2. Innovation Systems: State-of-the-Art

2.1. Conceptual Focus

A major contribution of the systemic approach is to put the stress upon the institutional set-up recognised as a key engine to foster organisational co-ordination, competition, and economic growth. In this research paper, we retain the definition of IS suggested by Kuhlmann and Edler (2003):

> "The innovation system of a society encompasses, according to a currently widely accepted understanding, the 'biotope' of all those institutions which are engaged in scientific research, the accumulation and diffusion of knowledge, which educate and train the working population, develop technology, produce innovative products and processes, and distribute them; to this belong the relevant regulative bodies (standards, norms, laws) as well as the state investments in appropriate infrastructures.

[2] Capron et al. (2000) for a presentation of the public authorities forming the Belgian NIS.

> The innovation system extends over schools, universities, research institutions (education and science system), industrial enterprises (economic system), the politico-administrative and intermediary authorities (political system) as well as the formal and informal networks of the actors of these institutions".

Several research scholars have provided a broader definition of innovation systems focusing either on their functional or spatial issues, as they all deal with the creation, diffusion and use of knowledge. Still, we shall develop our analysis merely thanks to the spatial features of IS.

The key concept of *National Innovation System* (NIS) has tackled many researchers since its original formulation over almost twenty years ago (Freeman, 1987, Dosi et al., 1988). According to Metcalfe (1995), NIS might be depicted as "that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which [national] governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies". Yet, the current view to limit the analysis of innovation systems to their *national* characteristics is increasingly challenged. Kaiser and Prange (2003) highlight that "tensions for NIS arise both from globalisation and regionalisation resulting first of all from increasing cross-border technological alliances of multi-national enterprises. Additionally, international science, innovation and diffusion networks turn nationally based systems of innovation into open systems". These limitations have stimulated efforts to analyse innovation system at different geographical levels of analysis.

The regional dimension of innovation systems has gradually gained scientific importance over the last years. As Cooke et al. (1997) emphasise, "it is the systemic co-operative, trust-dependent and associational character of regional innovation systems that make them such a valuable and interesting object of study". *Regional Innovation Systems* (RIS) cope with the perceived importance of the embedded local assets and priorities in the effectiveness of national STI performance. In other words, because the regions located in a country all have different comparative advantages, as well as formal and informal constraints[3], they all need to formulate different STI policy guidelines tailored to their local economy. Also, it is now recognised that proximity[4] favours local, intra-regional and inter-regional accessibility of knowledge (Andersson and Karlsson, 2002). Accessibility is an innovation process that increases the local or regional potential opportunities, the knowledge spillovers and so, in the end, the regional innovative capacity. Moreover, recent studies have put forward that spatial proximity matters in facilitating the transmission and acquisition of formal and tacit knowledge and is at the source of agglomeration economies[5]. So, within these concepts, we understand that this spatial level of analysis is becoming crucial in order to appreciate the overall mechanisms that transpire in a national innovation system. To sum up, as pointed out by Kaiser and Prange (2003), the RIS approach tries to explain how and to what extent the

[3] As pointed out by De Bruijn (2003): "Since regional politics inevitably involve geometrical elements like jurisdictional boundaries and elements of administrative power and responsibilities, the connection between relational networks and geometrical distance is a central element of enquiry". Moreover, they emphasise on the "geometrical aspects of cultural and institutional factors which are of great importance in explaining geometrical differences in the ability to respond to industrial change".

[4] Andersson and Karlsson (2002) define proximity as either geographical or relational (i.e. relations developed with the integration of firms and socio-cultural homogeneity; and untraded interdependencies and atmospheric externalities).

[5] Agglomeration economies are a powerful concept that helps explaining the advantages of the "clustering effect" of many activities ranging from retailing to transport terminals. They are usually distributed into three major categories: urbanisation economies; industrialisation economies; and localisation economies.

local institutions and the local cultural environment may support or hamper national innovative capacity.

On the other hand, two main arguments are also developed in favour of the existence of *Global Systems of Innovation*: first, the effects of national policies are diminishing, primarily given the increase of transnationally organised technologies and multi-national businesses; second, a growing number of policy areas are co-ordinated by the European Union or other regional integration agreements (*e.g.* NAFTA, MERCOSUR, etc).

Therefore, even though a *national* analytical basis is valuable because of the common conventions and rules shared by the institutional actors (*i.e.* linguistic, cultural, political and environmental constraints), the other analytical levels are of increasing importance. Lundvall et al. (2002) affirm that they are even useful in their own right: "Regional innovation policy calls for a focus on regional systems and understanding the evolution of global technological systems or sectoral systems is fundamental when it comes to define the needs for supra-national co-ordination and rule-setting". It is obvious that the national STI performance is closely related to the effective performance of the regions and localities. The regional feature is even central in the innovation system analysis because of the local characteristics and structural patterns that may have a deep impact on the competitiveness of the national innovation system (Kaiser and Prange, 2003). In a same vein, the supra-national priorities induce significantly the national and regional STI public initiatives[6].

2.2. Bridging Regional, National and Global IS: Territorial Innovation Systems and Innovative Milieu

Conceptualising IS through alternatively a specific geographical or functional frame aims to limit the complexity of the analysis in order to understand and measure their internal and external mechanisms. Lundvall (1998) argues that "it is only by breaking down national systems into the sub-systems that constitute them that we can understand how they develop". All arguments put on for each type of spatial analytical levels may be valid given the nature of the study analysis. Anyway lately a branch of authors have pointed out the interconnections that exist among all these levels of analysis and have recognised the central role played by each institution implemented at various territorial levels (beneath and above the nation-state). Subsequently, the concept of *Territorial Innovation System* has been defined as a "multi-level approach that aims to bridge the gap between IS approaches that analytically highlight one specific territorial level only" (Kaiser and Prange, 2004). These authors assume that "certain functions traditionally associated with the National System of Innovation have either been delegated towards other territorial levels or supplemented by those levels. In some cases those functions became part of a multi-level governance system in which institutional incentives and framework conditions are provided by various actors who share responsibilities across territorial levels".

In addition to this multi-level innovation governance, the current economic situation is characterised by ever broader globalisation and deregulation mechanisms. Hence, the local, regional, national and international development is becoming more complex than ever. As a corollary, scientific observations reveal either "lagging behind" regions that are excluded from the global development and still evolve in a centre-periphery model; or "winning"

[6] At the Lisbon European Council in March 2000, the European Union set itself a strategic goal for the next decade: to become the most competitive and dynamic knowledge-based economy in the World. The EU Council targeted EU R&D investment to rise from 1.9% of GDP (2000) towards 3% of GDP by 2010. The efforts of each EU Member States in order to achieve this EU global objective are reviewed and evaluated by the European Commission. In September 2002, the European Commission adopted a first Communication "*More research for Europe - Towards 3 % of GDP*" (COM(2002)499).

regions that constitute the active motion of economic systems and dynamically participate to the improvement of territorial systems. The concept of *innovative milieu*[7] helps to understand the economic success of some regions compared to others. The concept of innovative milieu is highly linked with territorial issues given that it emphasises all formal and informal regional comparative advantages (economic, environmental and institutional) through the development of territorial endogenous capabilities. Within this context, the institutional actors have understood the growing importance of the interactive learning mechanisms and the co-operative synergies that may be developed in a territorial context (Maillat and Kebir, 1999).

3. Components of IS

Whatever the geographical level of analysis, as well as the relevant level of decision-making, innovation is always considered as a complex system of interactions between different *institutions* aimed to fulfil some specific *objectives* through the efficient implementation of *instruments*. Yet, the territorial approach pinpoints that the instruments implemented at a given spatial level might be issued at other spatial levels, so that institutions should conceive innovation on a territorial outlook. The spatial dimension in this paper lies on the analysis of the Belgian institutional peculiarities as an introductory exercise for studying the European Innovation System in a further step.

3.1. Objectives of IS

The OECD (1996) states that "in the knowledge-based economy, the science system contributes to the key functions of: *i)* knowledge production – developing and providing new knowledge; *ii)* knowledge transmission – educating and developing human resources; and *iii)* knowledge transfer – disseminating knowledge and providing inputs to problem solving". Since the role of knowledge is generally accepted as the key engine of IS, it is then obvious that governments wish to better understand the processes of creation, distribution and use of knowledge in order to implement mechanisms that should boost their *national innovative capacity*[8]. Given this theoretical background, three generic categories of objectives are defined:

- **Creative Capacity** (*i.e.* knowledge production) mainly deals with the production of new scientific and technological knowledge. Yet, it also deals with activities located upward (*e.g.* launch of new innovative activities) and downward (*e.g.* commercial or social valorisation of new knowledge) the innovation process.

- **Transfer Capacity** (*i.e.* knowledge transfer[9]) is the sphere of the economy aimed to bridge the gap between the creation and the use of technology and know-how. Formal and informal transfer mechanisms may connect the institutional actors (*e.g.* scientific conferences, BELNET *Belgian national research network for education, research and public services*).

[7] Defined as a territorial structure within which the inter-relationships amongst actors are developing through multi-lateral learning processes that result in specific innovation externalities and effective territorial resources management (Maillat et al., 1994).

[8] Furman et al. (2002) define the concept of National Innovative Capacity as "the ability of a country – as both a political and economic entity – to produce and commercialise a flow of innovative technology over the long term". In other words, "national innovative capacity depends on the strength of a nation's common innovation infrastructure (cross-cutting factors which contribute broadly to innovativeness throughout the economy), the environment for innovation in a nation's industrial clusters, and the strength of linkages between these two".

[9] According to Bozeman (2000), "technology transfer is defined in many different ways according to the discipline of the research, but also according to the purpose of the research". Obviously, the same might occur with regard to knowledge transfer.

- **Absorptive Capacity** (*i.e.* knowledge transmission) "refers not only to the acquisition or assimilation of information by an organisation but also to the organisation's ability to exploit it. Therefore, an organisation's absorptive capacity does not simply depend on the organisation's direct interface with the external environment. It also depends on transfers of knowledge across and within sub-units that may be quite removed from the original point of entry" (Cohen and Levinthal, 1990). Here, we also return to the concept of "interactive learning" (Lundvall, 1992). Indeed, learning processes are fundamental in IS since "innovation is an *interactive process* where agents and organisations communicate, co-operate and establish long-term relationships" (Lundvall et al., 2002).

The creative, transfer, and absorptive capacities have been viewed as the main characteristics which allow to appreciate the efficiency in the production and exploitation of technology flows at the source of knowledge accumulation. Note that an efficient creative capacity implies a high level of transfer and absorptive capacities and a good transfer capacity should imply a high level of absorptive capacity. Each of these capacities has been subdivided in finest objectives released in the Appendix (Table A1).

3.2. Public Instruments for Innovation Systems

Nowadays, all modern economies adopt STI support policies in order to improve economic performance, social welfare, and development sustainability. The innovative role that public STI measures may play are extensively acknowledged: "Beyond simply increasing the level of R&D resources available to the economy, other policy choices shape human capital investment, innovation incentives, cluster circumstances, and the quality of linkages" (Furman et al., 2002). Kuhlmann and Edler (2003) define innovation policies as:

> "The integral of all state initiatives regarding science, education, research, technological development, and industrial modernisation. Thus, innovation policy is a broad concept that contains research and technology policy and overlaps with industrial, environmental, labour and social policies. Public innovation policy aims to strengthen the competitiveness of an economy, or of selected sectors, in order to increase societal welfare through economic success".

Nevertheless, it may be tough to limit innovation policies in a static frame since every public initiative might have an impact on the innovation system. Anyway, for the needs of our analysis, we suggest a taxonomy of the major instruments that may be applied in an IS. According to the 'Demsetz (1969) criteria': policy should balance among *encouragement* of a wide variety of experimentation (*i.e.* Framework measures), *direct* investment away from unpromising varieties of experimentation (*i.e.* Support measures), and promotion of the *dissemination* of knowledge as it is created (*i.e.* Diffusion measures). Given this statement, three generic categories of instruments are defined:

- The **STI Support measures** have been identified by the EC (2003) as "the main financial and fiscal instruments used either in isolation or in combination to stimulate R&D investment". *Direct measures* typically involve "the direct transfer of financial support from the public to the private sector". Through *indirect fiscal measures*, "the public sector forsakes tax income from the private sector in exchange for approved investment behaviour". Additionally, *risk capital measures* and *loan and equity guarantee measures* can be issued in order to "improve access to external private sources of finance and stimulate the flow of investment funds both for innovation in general and for R&D".

- The **STI Diffusion measures** are directly linked to the importance of creating an infrastructure that encourages a rapid spread of awareness and knowledge of innovation. It concerns "both expansion and relocation of knowledge" (Park, 1999). On the one hand, "diffusion policy increasingly addresses the 'facilitating structures' including the science-industry interface, firm networks or access to the information infrastructure" (OECD, 1998a). On the other hand, Hahn and Yu (1999) vindicate that "the true value of an invention should be evaluated through market forces", so that "*diffusion drives invention and innovation* rather than invention and innovation driving diffusion". This implies that the public measures devoted to the diffusion of science, technology and innovation should deeply understand the demand-supply inter-connections.

- The **STI Framework measures** are also a major condition for the successful implementation of STI policies. Indeed, the direct STI public initiatives should enter in a harmonised and sustainable economic context provided by sound macro-economic conditions, highly-qualified human reserve, and a reliable regulatory structure. As the OECD (1998a) pinpoints, "a distinction needs to be made between macroeconomic policies and framework conditions which promote diffusion as part of larger economic activity and the targeted diffusion policies which aim to raise innovation (and economic) performance in specific industries and firms by influencing the supply and the demand for technology and know-how".

3.3. Institutions in IS

The institutional set-up is at the core of the instrumentation in IS (local, regional or national)[10]. *Institutions*[11] are in charge of interventions making instruments operational. In fact, there is a myriad of institutions, which are expected to ensure the efficiency of innovation systems. They are not independent and vertical devices, but are intertwined by a game of hierarchical and/or causal relationships (*e.g.* policy-decision makers, S&T administrations, universities) and interdependencies (*e.g.* university-industry collaborations). Yet, it is now widely recognised that significant institutional mismatches coexist with market failures. Indeed, given that "institutions (formal or not) provide incentives, information and resources, reduce uncertainty, and attenuate conflicts" (Edquist and Johnson, 1997), Niosi (2002) puts forward "the possibility that some institutions involved in innovation may provide the wrong incentives, faulty information, or allocate insufficient resources to accomplish their goals or mandates; they may fuel conflicts and they may fail to reduce uncertainty". Subsequently, it is primordial to appreciate the internal and external linkages that tie institutions together. This calls for a clear view of the role played by the different categories of institutions within the innovation system. A first category of actors are the *Policy Recipient Institutions*. This generic term is defined as either the target institutions that benefit directly from the policy measure (*i.e.* large companies, SMEs, research centres, higher education institutions, public authorities, and individuals), or the bridging institution that behaves as a transition's actor between the policy issuer (*e.g.* the government's administrations) and the targeted institutions. In other words, the *Policy Recipient* is the institution that receives directly the funding linked to the measure. The *Policy Recipient Institution* may redistribute the funding afterwards to final target institutions. The methodological approach developed in the next section considers both categories of institutions as major components of innovation systems.

Hence, it is worth first describing the different categories of innovation institutions. For that purpose, the taxonomy retained is based on the OECD Frascati Manual (2002) that recognises five generic categories of innovation institutional actors: 1) business firms; 2) government institutions; 3) higher education institutions (HEI); 4) non-profit organisations;

[10] "The IS idea is an institutional conception, *par excellence*" (Nelson and Nelson, 2002).
[11] "Institutions understood as norms, habits and rules are deeply ingrained in society. They play a major role in determining how people relate to each other, and how they learn and use their knowledge" (Johnson, 1992).

and 5) the abroad sector. Three more categories may be added: 1) research and technology organisations (RTO); 2) bridging institutions; and 3) venture capital organisations. Indeed, it is now largely recognised that these institutions also play a key role in the innovation process.

- **Business Organisations:** It includes: 1) all firms, organisations and institutions (public and private) whose primary activity is the market production of goods and services (other than higher education) for sale to the general public at an economically significant price; and 2) the private non-profit institutes mainly serving them, such as industry and professional associations (OECD, 2002).

- **Government Policy Institutions:** It is composed of all departments, offices and other bodies which furnish but normally do not sell to the community those common services (other than higher education) which cannot otherwise be conveniently and economically provided; and which administer the state and the economic and social policy of the community (OECD, 2002).

- **Higher Education Institutions:** It is composed of all universities, colleges of technology, and other institutes of post secondary education, whatever their source of funding or legal status. It also includes all research institutes, experimental stations and clinics operating under the direct control of, administered by or associated with higher education establishments (OECD, 2002).

- **Research and Technology Organisations:** Most of them are technology-oriented research organisations[12]. Their activities largely concern applied research (*e.g.* pre-competitive research, near-the-market research, experimental development), though fundamental and/or social research areas might also be investigated with a particular focus on welfare and development issues. They may be "public or semi-public, private and/or subsidised through government funds" (Farina and Preissl, 2000). Also, international research teams might take part in RTOs' activities.

- **Bridging Institutions:** They are mainly composed with organisations that aim to exploit the results of research performed by HEIs and RTOs, to reinforce the absorption power of existing firms, and to promote the creation of new-venture firms and university spin-offs (Capron and Meeusen, 2000).

- **Venture Capital Organisations:** This category includes the different institutional actors that play a role during the formative stages of the company's life-cycles: seed, start-up, early growth, and established. These actors take a risk in trusting the launching of a new innovative activity. Venture Capital funds not only high technology industry, but also low technology industry (Zider, 1998).

- **Abroad Sector:** This sector consists of: 1) all institutions and individuals located outside the political borders of a country; and 2) all international organisations (except business enterprises), including facilities and operations within the country's borders (OECD, 2002).

[12] According to Farina and Preissl (2000), "attempts to define Research and Technology Organisations (RTOs) do not lead to satisfactory results because of the large variety of institutes and organisations, their purposes and configuration across countries. Whereas in some cases, the main contributors to the national technological knowledge base are universities, in others they are technology-specific or industry-specific research institutes. Some of them are public or semi-public, others private and/or subsidised through government funds. In a number of countries, RTOs are mainly technology-oriented; in others they also cover research on education, the social system, markets, or management issues. The range of tasks goes from predominantly basic research to technology transfer or applied research and even to implementation support".

- **Non-profit Organisations:** This sector includes: 1) non-market non-profit institutions controlled and mainly financed by government; 2) private non-profit institutions serving households (i.e. the general public); and 3) private individuals or households (e.g. citizens, individual researchers, entrepreneurs, students, consumers, etc) (OECD, 2002).

4. Methodology: Integrated Scheme for an Evaluation of Institutional Set-Ups

Recently, more and more importance has been given to the innovation institutional set-ups. As pointed out earlier, efficient STI governance is crucial for effective innovation performance. Yet, one can observe a lack of any strong methodological guidelines for the evaluation of innovation institutional set-ups. The objective of this paper is to propose a general framework for the empirical assessment of innovation systems from an institutional perspective. Subsequently, we suggest a classification method of the institutional set-ups of innovation systems. It is based upon the four following criteria: 1) *international comparability* of results; 2) *representativeness of results* with regard to the institutional profiles of countries; 3) *measurement issues* of the institutional mapping; and 4) *consistency* of the approach with regard to the concept of institutions.

Here, the stress has been put on the Belgian case study whose institutional peculiarity lies on a federal structure composed with a mix (and not a hierarchy) of national, regional and local systems each with their own political competences. The seven Belgian federated entities with their seven governments might then be viewed as an experimental lab to study in a further extent the European Union Innovation System.

The methodology implemented is based on the building of four functional matrices which are constructed by crossing objectives, instruments, and institutions that characterise the innovation systems (these generic terms have been defined here above):

- The *objectives-instruments matrix*, which describes the links between the STI objectives and the instruments used in order to fulfil these objectives;
- The *institutions-instruments matrix*, which establishes the links between the instruments and the institutions in charge of their implementation (*i.e.* policy recipient institutions);
- The *institutions-objectives matrix*, which illustrates the main functions managed by the policy recipient institutions;
- The *institutional interactions matrix*, which tries to identify the inter-connections between institutions playing a predominant role in the innovation systems and the final target institutions.

The study of the four functional matrices is relevant in order to deeply understand the articulations of the Belgian innovation process. Yet, in this paper, we only present functional matrices 1 and 4 for each spatial political level (see Tables A4 and A5 in the Appendix). We assume that these two matrices already explain a great deal of the innovation process, even though they eclipse the interactions that exist between the instruments and the institutional actors (*i.e.* functional matrix 2), as well as the interactions between the objectives and the institutional actors (*i.e.* functional matrix 3). Functional Matrices 2, 3 and 4 are built around the concept of *Policy Recipient Institutions*. Because this new concept is particularly complex, it will be deepened in a further step of the research.

Concretely, we first suggest a consistent taxonomy of the objectives, instruments, and institutional actors that prevail in innovation systems in general[13]. Then, we record the

[13] For a detailed taxonomy, see Tables A1 to A3 in the Appendix.

Belgian innovation policies at Federal, Regional and Community levels[14]. For each of these measures, we identify their specific objectives, instruments, and institutions according to the taxonomy primarily defined. At the same time, we agree on near-to-reality 'distribution keys' related to each objective, instrument, and institutional actor. Indeed, we need to determine these in order to avoid the double-counting of the policy measures in the matrices. Each measure has an equal weight in the database (whatever their relevance or quality of financial weight). These assumptions are especially needed when the policy measure is aimed at several objectives; and/or is implemented through different instruments; and/or is targeted to different institutional actors. Ultimately, we evaluated the Belgian institutional mapping in Science, Technology and Innovation by crossing these objectives, instruments and institutions into four qualitative functional matrices that should all together describe the whole national and regional innovation process. This top-down approach has allowed us to strengthen the validity of the taxonomy used.

As a result, the functional matrices depict the distribution of the measures given their related objectives, instruments, and institutions. These matrices are expressed in percentage of all STI measures for each federated entity. It is worth keep in mind that they tell us nothing on the quality and effectiveness of the measures. Rather they attempt to show the STI issues prioritised by the Regional and Federal Governments (*i.e.* STI regional policy mix). The higher the value of a cell is, the more diversified are the instruments implemented to achieve the targeted objective. Although, the results must cautiously be interpreted since, on the one hand, one great issue might be addressed by a major single measure (with substantial financial and human means), and, on the other hand, many soft measures might be targeted to solve minor issues. In the next section, we shall evaluate the Belgian innovation system and its spatial specificities.

5. Case Study: The Belgian Regional Innovation System

The Belgian innovation policy is characterised by the complex legal framework of the country. Indeed, Belgium has become a regionalised country three decades ago and officially a federal country ten years ago. Belgium is now composed of seven different federated entities[15]: Federal State, Brussels-Capital Region, Walloon Region, Flemish Region, Flemish Community, French-speaking Community, and German-speaking Community. As pointed out earlier, this Belgian peculiarity might be viewed as an experimental lab to study in a further extent the European Innovation System. Note that, for the purpose of our analysis, regional and community measures have been aggregated. So, we work with four different entities: 1) Flemish Community; 2) Brussels-Capital Regional + French Community; 3) Walloon Region + French Community; and 4) Federal State.

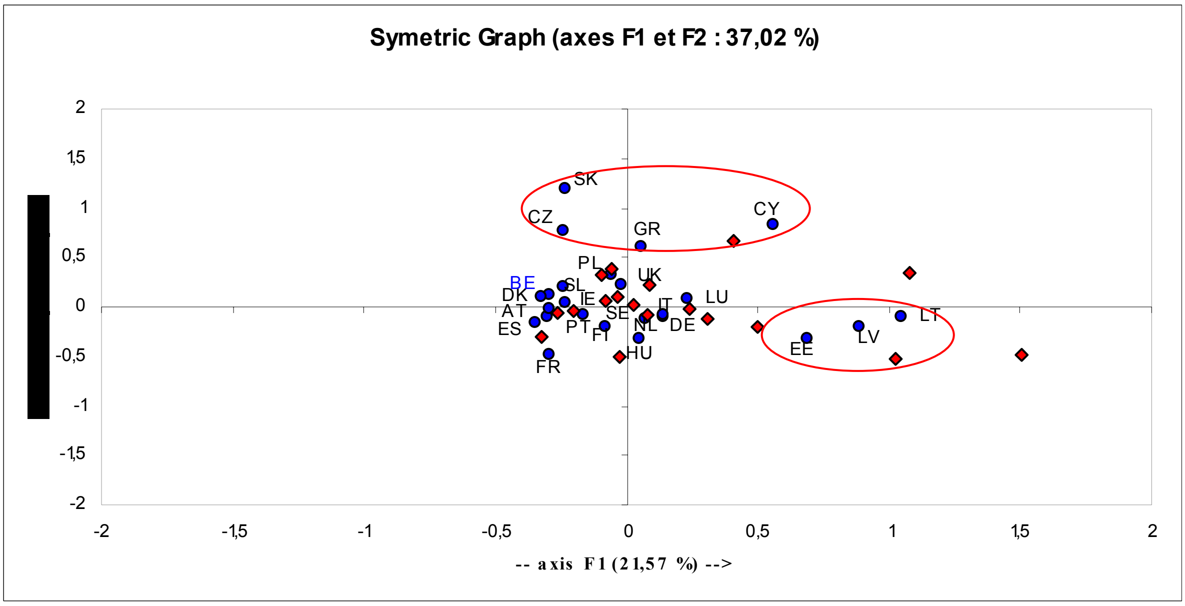
[14] For this exercise, we used two main data sources that provide a comprehensive list of the Belgian policy measures initiated for STI enhancement: 1) the EU Innovation Trend Chart (CORDIS, http://trendchart.cordis.lu/); and 2) the Belgian Report on Science, Technology and Innovation (OSTC, 2001, http://www.belspo.be). Although we do not assume the exhaustiveness of these policy databases, we consider that they are representative of the main STI public initiatives. Anyway, national governments are responsible for the good representativeness of these documents.

[15] Each federated entity has its specific competences (OSTC, 2001): - Regions have the main responsibility for economically oriented research, technological development and innovation promotion. - Communities have the main responsibility for fundamental research in universities and applied research in higher education establishments, as well as cultural and other individual matters, such as health policy, and personal assistance. - The Federal State is competent for research of national interest (e.g. Space Research); Federal Scientific Institutes; programmes and actions requiring homogenous execution at national or international level; Belgian collaboration in activities of international research bodies (e.g. CERN); maintenance of permanent inventory of the country's scientific potential (i.e. R&D and innovation statistics); and any action in areas belonging to the competences of the Communities or Regions, and which furthermore are either related to an international agreement or refer to actions and programmes going beyond the interests of one Community or one Region.

5.1. European Innovation System in Prospect

We first proceeded to a correspondence analysis[16] of innovation policy measures reported in the EU Trend Chart policy database[17] in order to position Belgium within the European innovation area (Chart 1). Even though the objectives identified in this database are different from our taxonomy, it provides a relevant starting point to compare the STI governance of the EU Member States (MS) and the location of Belgium amongst the other EU countries. Given regional and territorial issues, we should keep in mind that it is tough considering the EU as a homogeneous whole. Instead the European IS should be regarded as “a polarised system with many centres rather than a single system” (Andersson and Karlsson, 2002).

Chart 1. Factorial Analysis of Correspondences of European National STI policies



Notes: AT=Austria; BE=Belgium; CY=Cyprus; CZ=Czech Republic; DE=Germany; DK=Denmark; EE=Estonia; ES=Spain; FI=Finland; FR=France; GR=Greece; HU=Hungary; IE=Ireland; IT=Italy; LT=Lithuania; LU=Luxembourg; LV=Latvia; NL=Netherlands; PL=Poland; PT=Portugal; SE=Sweden; SK=Slovak Republic; SL=Slovenia; UK=United Kingdom. No data for Malta.

In Chart 1, axis F1, which explains 21.57% of the variance, clearly distinguishes the Baltic countries from the other EU-25 MS. The STI policy of these three countries is characterised by a high concentration of actions dealing with ‘competition’, ‘legal and regulatory framework’, and ‘administrative simplification’. Axis F2, which explains 15.46% of the variance, also highlights a distinct set of countries (*i.e.* Slovakia, Czech Republic, Cyprus, and Greece). Compared to the other EU-25 MS, these countries have the peculiarity to concentrate a relative majority of their STI actions to ‘strategic vision of R&D’ (over 10% of total measures). The distribution of the STI actions of the other new adherent countries (*i.e.* Hungary, Poland, and Slovenia) is comparable to the States of the former EU-15. Note that the other axes put forward the “within” peculiarities of the EU-15 IS.

As far as Belgium is concerned, we can observe that it shares the same major STI priorities as Denmark and Slovenia, and, to a smaller extent, as Austria. These STI priorities are strengthening company research, start-up of technology-based companies, co-operation between universities, research institutes and companies, and absorption of technologies by SMEs (over 10% of total measures). Given this statement, we now continue with an in-depth analysis of the Belgian IS on the basis of the taxonomy developed here above.

[16] Factorial Analysis of Correspondences consists in retrieving the best simultaneous representation of two data sets that forms the lines and columns of a contingency table. These two data sets play a symmetric role.
[17] See http://trendchart.cordis.lu/.

5.2. The Belgian STI Profile

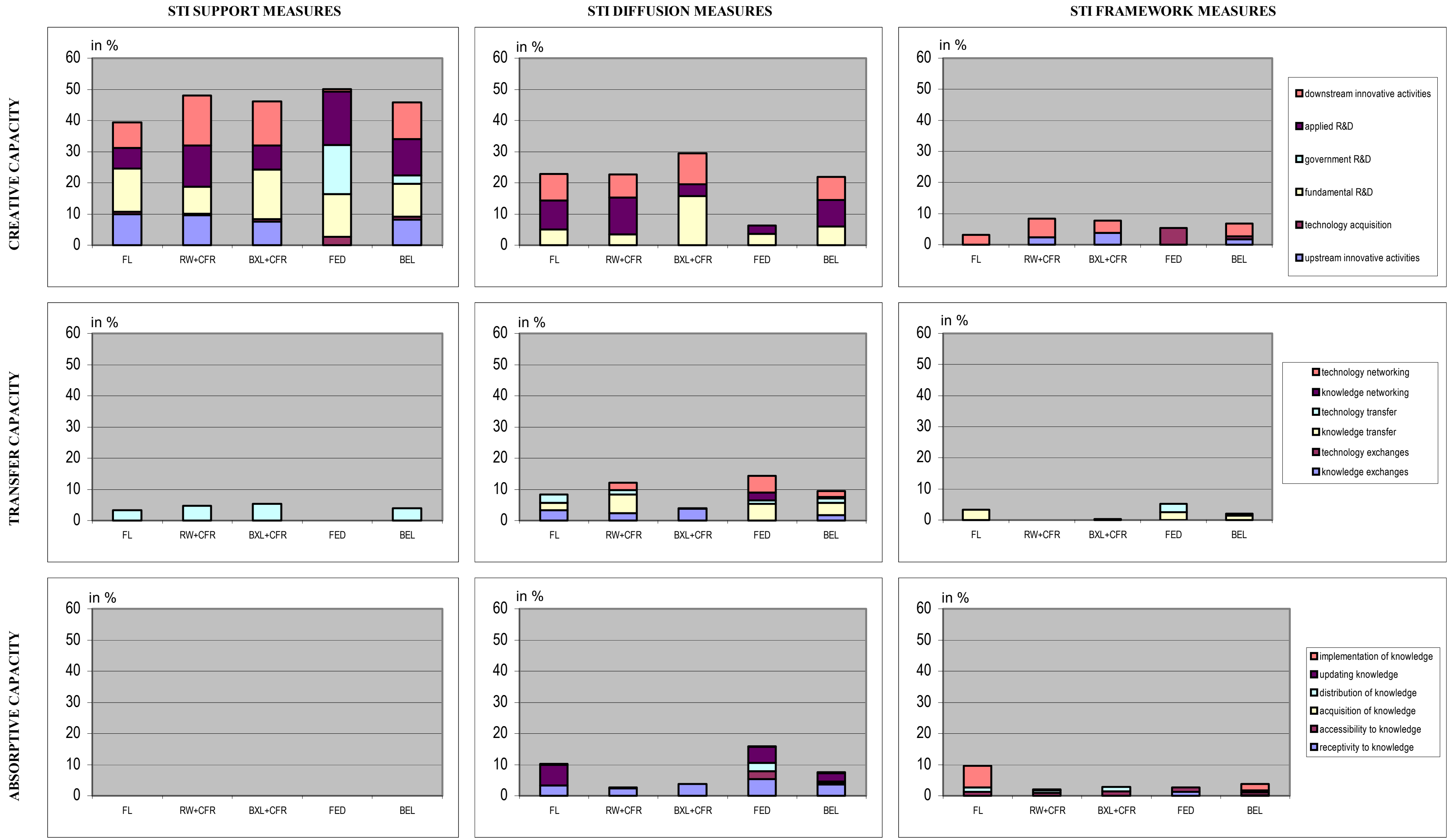
According to the European Trend Chart of Innovation (2003), the Belgian STI priority is mainly stressed upon public initiatives for 'Gearing Research to Innovation', especially by strengthening research carried out by companies and by supporting start-ups of technology-based companies (though the rankings assigned to these action lines cannot be considered of so high level compared to other EU countries). These two priorities are covered under four main support mechanisms that characterise the strengths of the Belgian Innovation System: 1) fiscal incentives; 2) mobility measures; 3) venture capital investment; and 4) R&D collaborations support. However, due to the specific Belgian institutional framework, some major spatial disparities can clearly be identified.

At the Federal level (see Charts 2 & 3 and Table A4 in the Appendix), the stress is put on the Creative Capacity. R&D activities are mainly supported through direct grants (23.7%). Yet fiscal incentives represent a great deal of Federal actions. The EU Trend Chart of Innovation (2003) highlights the innovation financing measures as a key tool for Belgium (e.g. fiscal incentives for R&D investment; for new R&D personnel; co-ordination centres). Almost 20% of Federal STI initiatives are of fiscal nature. Another central Federal instrument concerns the support for the diffusion of STI in society (15.8%). These measures are intended to facilitate the promotion and use of new products, processes, services, and innovative activities among the institutional innovation actors. This statement is strengthened by the fact that 38.2% of the instruments aim at improving the Transfer (19.5%) and/or the Absorptive Capacity (18.7%).

According to Chart 4 (Table A5 in the Appendix), research centres are the main institutions targeted by the Federal STI policies (about 43.7%). These research institutes mainly consist of: inter-university research centres (e.g. Inter-University Attraction Poles); federal scientific institutions (e.g. Royal Meteorological Institute, Belgian Institute for Space Aeronomy); international research organisations (e.g. CERN); collective research centres; etc. The business organisations benefit also largely from Federal measures (19.5% for large companies and 11.1% for SMEs). Finally, about 20% of the measures are targeted to individuals; they mainly concern public awareness initiatives.

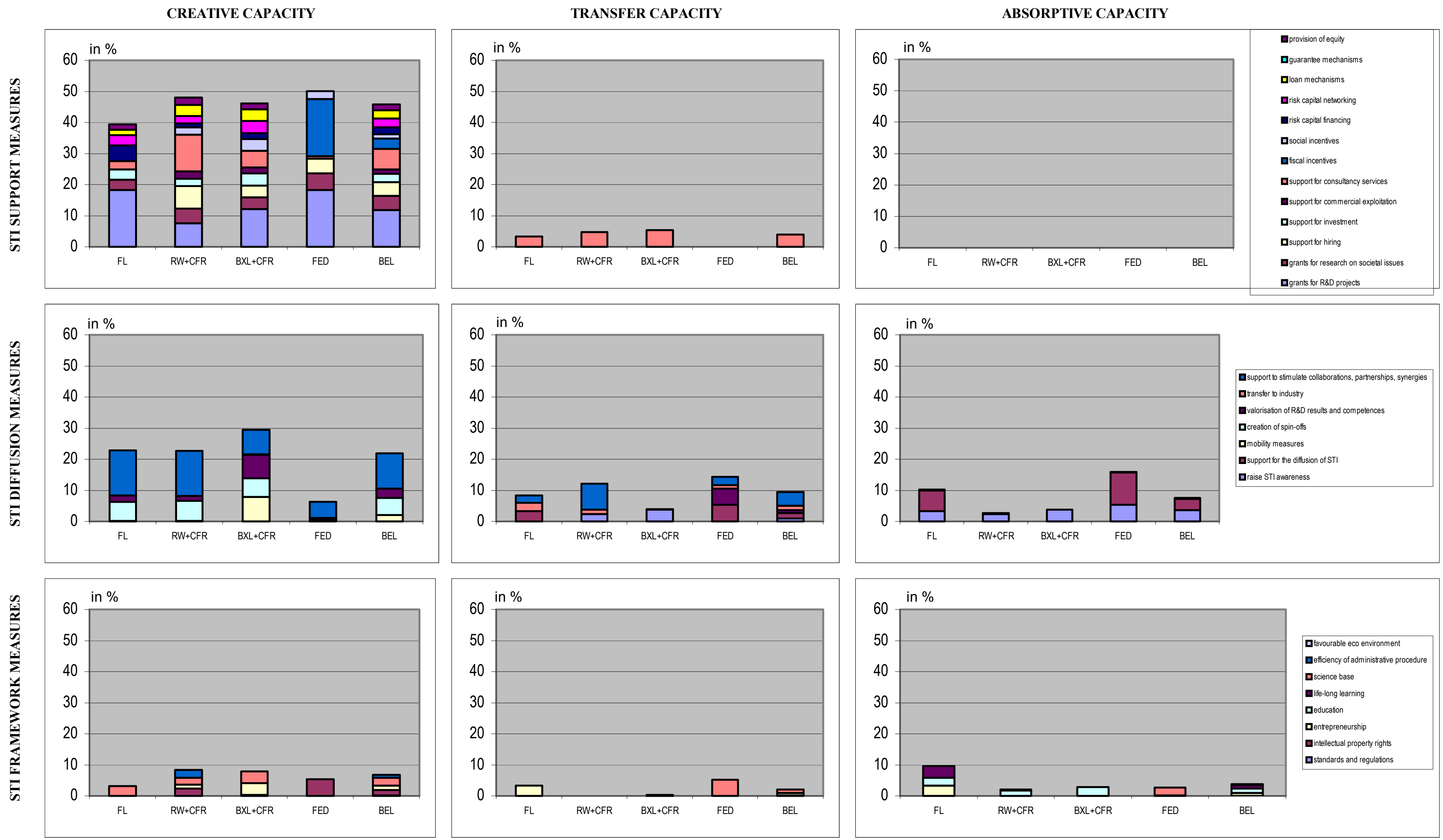
The regional matrices (see Charts 2 & 3 and Table A4 in the Appendix) suggest that the priority of the regions is mainly concentrated around the Creative Capacity (65.2% for Flanders; 83.6% for Brussels; and 78.6% for Wallonia). The regions focus their means especially in fundamental and applied R&D activities, as well as in downstream innovative activities. As the Walloon Region stresses collaborative research as a main support tool (22.8%), the Flemish Community and Brussels-Capital Region finance more their R&D activities directly through R&D grants (21.5% for Flanders; 15.9% for Brussels; and 12.3% for Wallonia). Though, the Flemish Community provides also good support to collaborations and partnerships (16.9%). Also, the three regions devote a large part of their subsidies to the support for consultancy services, especially in the Walloon Region (16.5%). The Flemish Region seems to be the only region aware of the importance of the diffusion process of new technologies among the social players (10% of its actions are devoted to this instrument). In a same vein, 34.9% of the STI Flemish actions aim either at the Transfer (15%) or the Absorptive Capacity (19.9%). As in the two other regions no measures are initiated in that field. Last but not least, a great part of the regional measures are devoted to risk capital and entrepreneurship. In Flanders, risk capital measures (8.3%) and mechanisms to ease the creation of spin-offs (6.2%) and an entrepreneurial culture (6.7%) represent 21.2% of all measures. Respectively, these measures amount 15.5% in the Brussels-Capital Region and 11.2% in the Walloon Region. According to the EU Trend Chart Thematic Reports (2003), "Belgium is relatively well placed in terms of the raising and investment of risk capital".

Chart 2. Functional Matrix 1: Classification by STI Policy Objective (in % of total STI policy measures – expressed per detailed objective)



Notes: FL = Flemish Community; RW+CFR = Walloon Region + French Community; BXL+CFR = Brussels-Capital Region + French Community; FED = Federal State; BEL = Belgium.

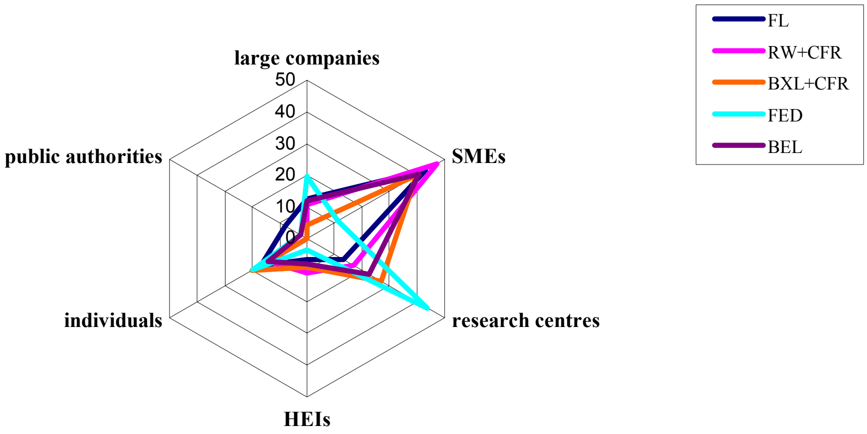
Chart 3. Functional Matrix 1: Classification by STI Policy Instrument (in % of total STI policy measures – expressed per detailed instrument)



Notes: FL = Flemish Community; RW+CFR = Walloon Region + French Community; BXL+CFR = Brussels-Capital Region + French Community; FED = Federal State; BEL = Belgium.

Indeed, “all governments in Belgium place strong emphasis on fostering entrepreneurship and the creation of new firms through measures aimed at: simplifying the procedures for registering and operating companies, one-stop-shops for financial aid and advice services, support for incubator type structures, etc”.

Chart 4. Belgian Final Target Institutions (in % of total Target Institutions)



Note: FL = Flemish Community; RW+CFR = Walloon Region + French Community; BXL+CFR = Brussels-Capital Region + French Community; FED = Federal State; BEL = Belgium.

Given Chart 4 (Table A5 in the Appendix), the regional measures are mainly targeted to business organisations (from 57.9% in Wallonia to 55.5% in Flanders and 44% in Brussels) of which a large part is devoted to SMEs (43.1% in Flanders; 39.8% in Brussels; and 47.2% in Wallonia). However, regional differences exist in the policy recipient institutions. As in Flanders the co-ordination support and promotion organisations co-ordinate almost 25% of all measures (due to the large role of the *Institute for the Promotion of Innovation by Science and Technology in Flanders*), in the two other regions the policy measures are usually directly implemented. In the three regions, (inter-)university research centres represent a great deal of policy measures especially in the Brussels-Capital Region (10.8% in Flanders; 29% in Brussels; 13.5% in Wallonia). Yet, in the Flemish Community, 10% of the measures are targeted to private research centres and competence poles (e.g. IMEC *Interuniversity MicroElectronics Center*, VITO *Flemish Institute for Technological Research*). Also, bridging institutions play a greater role in the Flemish Community (29.9%) than in the two other Regions (22% in Brussels; 15.6% in Wallonia). This is especially due to the contributions of incubators and business centres.

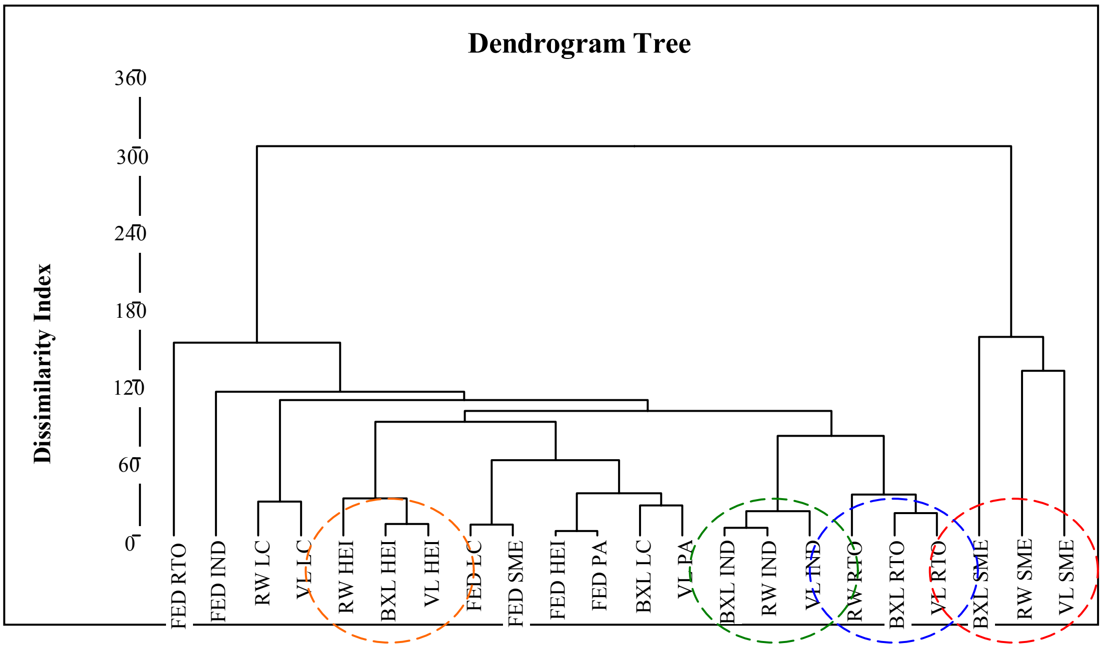
The assumptions drawn by the Belgian Functional Matrices lead us to depict the Belgian Innovation System mainly by its strong willingness to reinforce all R&D collaborative mechanisms. With more than 15% of all national STI initiatives, it is known that “the Belgian participation in European R&D programmes is very high compared to other Member States. The weight of Belgian collaborations with neighbouring countries is particularly important” (Capron and Cincera, 1999). However, not only an intensified co-operation between research, universities and companies is needed to succeed in an innovative economy, to ‘establish a framework conducive to innovation’ and to ‘foster an innovation culture’ are also crucial action lines to take (EU Trend Chart, 2003). Unfortunately, the Belgian Authorities do not seem to take effective initiatives in that matter.

5.3. Belgian Regional Innovation System: First Conclusions

We used two data analysis techniques in order to further treat our policy database. Chart 5 illustrates the dendrogram tree which results from an ascending hierarchical classification[18] (AHC), as Chart 6 represents a factorial analysis of correspondences (FAC).

According to the ascending hierarchical classification analysis (Chart 5), two major conclusions can be drawn up. First, it seems that the three regions issue the same kinds of initiatives targeted to the HEIs, RTOs, individuals, and SMEs. But, in a second step, one can also remark that the regional initiatives targeted to SMEs are largely isolated from all the other STI public measures. Given this statement, we can presume that there is a strong will for an original entrepreneurial policy in the Belgian regions. Of course, recall that these results tell us nothing on the quality and effectiveness of the measures. Note that we used the Euclidian distance as dissimilarity measure according to the Ward method for the aggregation criteria.

Chart 5. Belgian Spatial Target Institutions: Ascending Hierarchical Classification

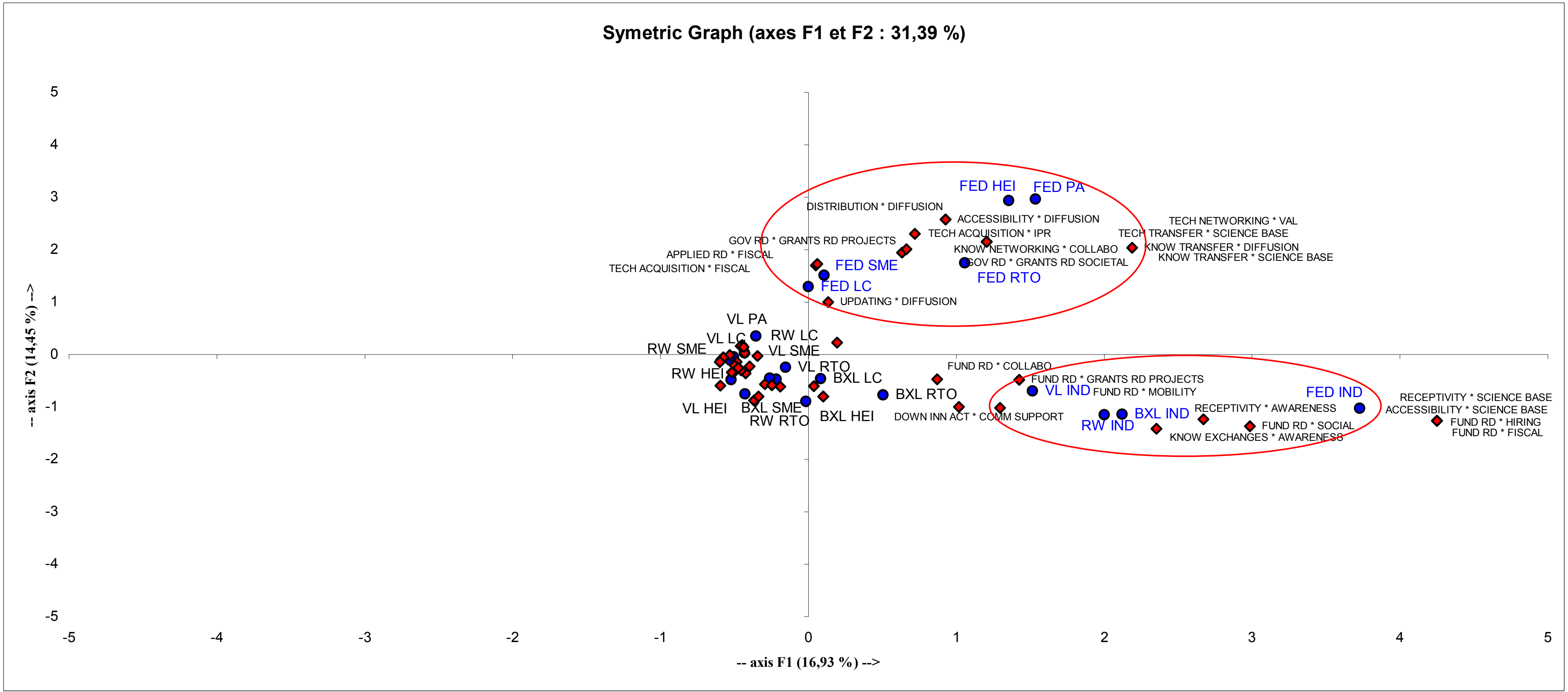


Notes: VL = Flemish Community; BXL = Brussels-Capital Region + French Community; RW = Walloon Region + French Community; FED = Federal State.
LC = large companies; SME = small and medium enterprises; PA = public authorities; HEI = higher education institutions; RTO = research and technology organisations; IND = individuals.

According to the factorial analysis of correspondences, we notice that two main blocks can be distinguished (Chart 6). The first block assembles the great majority of federal STI initiatives (except the ones targeted to the individuals). This assumption makes sense since the STI federal competences are very specific and have nothing in common with the other regional and community competences. As we can see on Chart 6, STI federal initiatives may be distributed among four main instruments: 1) Fiscal incentives for large companies and

[18] This method consists in progressively aggregating the individuals according to a similarity (or dissimilarity) index. The algorithm begins with assembling the couples of individuals the most alike, and then progressively aggregates the other individuals or groups of individuals with the same criteria of aggregation until the totality of the individuals forms a major single group. As a result, UHC build a binary classification tree, called a Dendrogram Tree.

Chart 6. Factorial Analysis of Correspondences of Belgian Spatial Target Institutions



Notes: VL = Flemish Community; BXL = Brussels-Capital Region + French Community; RW = Walloon Region + French Community; FED = Federal State.
LC = large companies; SME = small and medium enterprises; PA = public authorities; HEI = higher education institutions; RTO = research and technology organisations; IND = individuals.
TECH ACQUISITION = technology acquisition; FUND R&D = fundamental R&D; GOV R&D = government R&D; APPLIED R&D = applied R&D; DOWN INN ACT = downstream innovative activities; KNOW EXCHANGES = knowledge exchanges; KNOW TRANSFER = knowledge transfer; TECH TRANSFER = technology transfer; KNOW NETWORKING = knowledge networking; TECH NETWORKING = technology networking; RECEPTIVITY = receptivity to knowledge; ACCESSIBILITY = accessibility to knowledge; DISTRIBUTION = distribution of knowledge; UPDATING = updating knowledge; GRANTS RD PROJECTS = grants for R&D projects; GRANTS RD SOCIETAL = grants for research on societal issues; HIRING = support for hiring; COMM SUPPORT = support for commercial exploitation; FISCAL = fiscal incentives; SOCIAL = social incentives; AWARENESS = raise STI awareness; MOBILITY = mobility measures; DIFFUSION = support for STI diffusion; COLLABO = support to stimulate collaborations/partnerships/synergies; VAL = valorisation of R&D results and competences; IPR = intellectual property rights; SCIENCE BASE = science base.

SMEs; 2) R&D grants for governmental projects; 3) Diffusion mechanisms; and 4) Reinforcement of the scientific base. The second block brings the individuals of each federated entities together. This means that, at each political level, the authorities issue the same kinds of instruments tailored to the individuals. To a large extent, these instruments are directly linked to fundamental R&D (*e.g.* R&D grants, support for hiring, mobility measures, fiscal incentives, social incentives), although they may also concern initiatives to raise STI public awareness and mechanisms to support the commercial exploitation of R&D results by individuals. Note that the two first axes of the FAC analysis explain 31.4% of the variance (respectively, 16.93% and 14.45%), the other axes stressing the other STI priorities of regional targeted institutions. The degree of similarity-dissimilarity between the regional institutions is summarised in the dendrogram tree (Chart 5) as shown here above.

6. Further Developments

In this paper, we provided a scheme of the three main building blocks of innovation systems in general (*i.e.* Objectives, Instruments, and Institutions). We showed that the matrices' approach might explain innovation systems and, especially, the interconnections that exist between the different STI players, their functions and their activities. However, in order to ensure the validity of the approach, we shall replicate the Belgian exercise to the other EU-15 Member States. This will first allow us to consolidate the taxonomy of the components of innovation systems. Second, we shall also be able then to compare the strength of our taxonomy to other already existing innovation taxonomies (*e.g.* EU Trend Chart, OECD, 1997b). Subsequently, we expect to contribute to the existing literature by suggesting a useful classification method of the institutional set-ups of Innovation Systems at local, regional and national level.

Another research track would consist in quantifying these matrices with representative composite STI indicators at national and regional levels. Indeed, without the recourse to quantitative indicators, it becomes tough to draw up grounded conclusions on the performance of innovation systems. Hopefully, it is expected to design an analytical framework that could be replicated in other industrialised countries.

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Appendices

Table A1: Taxonomy of Objectives

Creative Capacity	
Upstream Innovative Activities	Initiatives in order to ease the creation of start-ups and innovative enterprises and open up new markets for promising products, processes and services; improvement of the equity capital base of organisations; improvement of competition by innovation enhancement; encouraging enterprises' STI investment; promotion for new innovative activities within enterprises; support for feasibility studies and highlight of innovation opportunities; etc.
Technology Acquisition	In order to promote technology upgrading through the introduction and utilisation of modern and efficient technology in the manufacturing and physical development of existing and new products or processes; as well as to enhance the competitiveness level of firms to enable them to compete globally. Technology acquisition may include: technology licensing; acquisition of patent rights, prototypes and design; training; and foreign expert sourcing.
Fundamental R&D	It refers to the research and experimental development activities mainly carried out by the Higher Education Institutions.
Applied R&D	It refers to the research and experimental development activities mainly carried out by the Private Organisations and the Research Institutes (public or private).
Government R&D	It refers to the research and experimental development activities ordered by the public Authorities.
Downstream Innovative Activities	Other preparations for production linked to innovative activities: tooling up and industrial engineering, development of prototypes, design, other capital acquisition, production start-up, marketing for new or improved products, training, and software (definition derived from the Oslo Manual).

Transfer Capacity	
Knowledge Exchanges	Informal interactions among the actors that facilitate upstream and downstream linkages on tacit knowledge. By instance: forums, scientific conferences, etc.
Technology Exchanges	Informal exchanges of technology among the actors of the innovation system. By instance: feedback opinions from final users on a product, process, or service.
Knowledge Transfer	Formal transfer of know-how and/or technical knowledge from one organisational setting to another. It may comprise informal knowledge exchanges.
Technology Transfer	Use of the technology or technical information outputs (e.g. patents, licences, dissemination of equipment, technical information, related skills to users, etc) issued by a party external to the project. Technology transfer may occur at each stage of the innovation process, as technology acquisition only takes place in the launching of new innovations. It may comprise informal technology exchanges (Kingsley et al., 1996).
Knowledge Networking	When knowledge is shared, developed and evolved. It is more than access to information, because it also looks into the unknown. It is more than using the rules and inferences of expert systems, because it is about knowledge that is evolving.
Technology Networking	Share of existing technologies and development of these technologies, and related R&D activities, through the contribution of different innovation actors. It builds up R&D group activities while tighten close co-operation. It may comprise technology informal exchanges and technology transfer.

Absorptive Capacity	
Receptivity to Knowledge / Technology	In order to enhance the human capabilities and awareness for learning new or existing knowledge and/or technologies.
Accessibility to Knowledge / Technology	It can be defined as a well-shaped completeness of education and training channels, as well as all other socio-economic process. By instance, the society needs to offer the largest range of higher education institutions, vocational training institutions, and apprenticeship institutions that should provide a wide variety of educational and professional tuitions/degrees.
Acquisition of Knowledge / Technology	It embodies goods and services purchases, reverse engineering, and physical capital investment. It is directly linked to the infrastructure and the operational functioning of the innovation institutional actors (e.g. universities, research institutes, etc), and is not devoted to the innovative activities in themselves.
Distribution of Knowledge / Technology	Adequacy and quality of the knowledge/technology transmission system (e.g. education, training, administrative procedure, etc).
Updating Knowledge / Technology	Capability of learning and applying new skills. Diffusion of new knowledge/technology to the innovation institutional actors (e.g. business organisations, public authorities, population, etc).
Implementation of Knowledge / Technology	It embodies: hiring of human capital, human capital mobility, use of new or existing technologies, and linkages between education, vocational training and the professional world.

Table A2: Taxonomy of Instruments

STI Support Measures	
Direct measures	It includes: 1) grants for R&D projects; 2) grants for research on societal issues; 3) subsidies for hiring new STI personnel; 4) subsidies for R&D investment (material or immaterial); 5) subsidies for commercial exploitation of R&D results; 6) subsidies for consultancy services; 7) public technology procurement.
Indirect measures	All support scheme not directly linked to R&D and innovation activities. 1) Fiscal schemes (i.e. tax incentives) may contribute to increase the overall STI investment. 2) Improvement of the social status of R&D and innovation personnel.
Risk Capital measures	Instruments affecting the flow and use of risk and use of risk capital for innovation-related activities likely to increase R&D levels in the long-term, typically via routes which encourage investment in spin-offs, start-ups and NTBFs and the establishment of dynamic, high-tech, research-intensive SMEs. It includes: 1) risk capital financing measures; 2) risk capital networking measures.
Loan and Equity measures	1) loan mechanisms (e.g. participative loans, restructuring financial loans, subsidies on the interest rate, etc); 2) guarantee mechanisms (e.g. bank credit guarantee, public guarantee for equity investment, guaranteed loans for investments, etc); 3) provision of equity (local and regional) in order to help growing or new businesses.

STI Diffusion Measures	
Raise STI awareness	Actions here reflect the stimulation of public awareness and acceptance of STI, the stimulation of consumer demand for technological novelty, innovation in forms of social organisation, management and communication, technological awareness, and measures which affect the attitudes, values and positions of the social groups involved towards aspects of innovation.
Support for the diffusion of STI	Public measures intended for facilitating the promotion and use of new products, processes, services, and innovative activities among the institutional innovation actors. Also external experts might share their experience with firm managers in order to learn other technology development proceedings.
Mobility measures	Mobility of students, research workers, engineers and scientists from one country/region or industrial sector to another, and from education of research institutes to industry. In order to encourage the transfer of technology and the dissemination of know-how.
Creation of Spin-offs	It includes all public initiatives designed to assist graduates/researchers in establishing their own business, especially through the valorisation of their R&D results, particularly on-campus site (i.e. spin-offs). It aims at stimulating an entrepreneurship spirit.
Valorisation of R&D results and competences	Public initiatives in order to help in the commercial exploitation of R&D results and competences.
Transfer to Industry	It concerns industry adoption of new technologies and diffusion through capital equipment. Public measures may be needed in order to improve firms' access to new technologies, to promote the implementation of these technologies, and to strengthen the technical competence in industry (OECD, 1998).
Support to stimulate collaborations, partnerships, synergies	It includes: 1) interactions among enterprises, primarily joint research activities and other technical collaborations; 2) interactions among enterprises, universities and public research institutes, including joint research, excellence poles, co-patenting, co-publications and more informal linkages; 3) innovation supporting institutional interactions, such as research and engineering facilities; and 4) promotion of clustering and co-operation for innovation (OECD, 1998).

STI Framework Measures	
Standards and Regulations	Regulations generally set constraints on behaviour and specify the penalties for not abiding by the rules, whereas conformity to standards can often be voluntary. They cover fields as diverse as environment, health, safety, and social standards (EC, 2003).
Intellectual Property Rights	It covers: harmonisation of intellectual property rights system, reducing complexity and costs associated with patenting and the maintenance of patents, hastening the formulation and adoption of standardised patent criteria and rules of legal protection, exchange of IP best practice, dissemination of awareness and information on IP protection and patents (EC, 2003).
Entrepreneurship	SMEs, start-ups, spin-offs, and NTBFs are vital ingredients in the drive to boost R&D expenditure, increase innovation and enhance economic growth. Public actions may be needed in order to facilitate this process (EC, 2003).
Education	Education plays a prominent role in the effectiveness of the NIS. No economic or social development can be achieved without the availability of an educated and properly qualified working force. It includes initial education and higher education.
Life-Long Learning	It includes: continuing or further training, vocational training within the company, apprenticeship, on-the-job training, seminars, distance learning, and evening classes.
Science Base	It includes a high-quality education sector (primary, secondary and third levels); public scientific organisations; Information Society infrastructures (e.g. Internet); scientific parks; scientific prizes; "label of excellence"; etc (EC, 2003).
Efficiency of Administrative Procedure	Excessive bureaucracy and administrative overheads are recognised as potential barriers to innovation. This category covers measures designed to streamline administrative practices and may include the provision of on-line application processes, specialised help-line or advisory services, "one-stop-shops", simplification or transparency of eligibility conditions, simplified payment procedures, streamlined tendering procedures, etc.
Favourable Economic Environment	Measures linked to the macro-economic conditions, competition and the general fiscal environment. Also, measures for sustainable development (EC, 2003).

Table A3: Taxonomy of Institutions

Business Organisations	
Large Companies	Private or public firms (> 250 persons) whose prime activity is the market production of goods and services (other than higher education) for sale to the general public at an economically significant price.
Small and Medium Enterprises	Private firms (< 250 persons) whose prime activity is the market production of goods and services (other than higher education) for sale to the general public at an economically significant price. In this category, one also finds all new technology-based firms (e.g. start-ups, spin-offs).
Private Research Centres & Competence Poles	Business organisations may carry out R&D activities in direct purpose of profitable commercialisation of R&D results. Competence poles group the R&D infrastructure of several companies in order to gain scale economies in the production, distribution, and all other services connected to R&D activities.
Industry & Professional Associations	They collect and disseminate market and technical information. They are typically created and managed by associations of businesses whose services they are designed to promote, such as chambers of commerce, and professional associations.
Consultancy Firms	Their main purpose consists in technical expertise, advisory services, technology brokering, etc.

Government Policy Institutions	
Parliament & Ministries	They elaborate the S&T policy and decide the allocation of resources between conflicting objectives.
Local & Regional Authorities	Given other political spatial level, these Authorities might also elaborate their STI policy according to their competences and resources.
Co-ordination Support & Promotion Organisations	They aim at implementing the governmental S&T strategy and S&T programmes, as well as to provide the institutional support in order to ensure an efficient co-ordination of the STI public initiatives amongst the actors.
Advisory Bodies	Such as Research Councils, S&T policy Councils, academies, S&T committees.
Regulatory Agencies	They are responsible for the assignment of intellectual property rights, standards, norms and certifications.
Supra-National Institutions	They aim at promoting international co-operation, inter-governmental co-operation.

Higher Education Institutions (HEI)	
Higher Education Institutions	It is composed of all universities, colleges of technology, and other institutes of post secondary education, whatever their source of finance or legal status. They provide post-secondary education and carry out R&D activities. It also includes all research institutes, experimental stations and clinics operating under the direct control of or administered by or associated with higher education establishments (Frascati Manual, 2002).

Research and Technology Organisations (RTO)	
(Inter-)University Research Centres	Interdisciplinary research centres, or excellence centres, that do some scientific and applied research. It can be inter-university research centres.
Central Services and Scientific Institutions	Federal, regional or local organisations which are devoted to the basic and/or applied research on a given scientific field (Gill, 2002).
Public and Semi-Public Research Centres	They are distinctive organisations in the research sector: they are more "mission-oriented" than universities, yet unlike the research departments of private companies, that mission is not primarily about profit for the organisation itself, but about contributing to the health of the national economy and/or to the "public good".
International Research Communities	Scientific associations and forums, international scientific co-operation, network of institutions, joint facilities, etc.
Joint Research Organisations	They aim to meet the specific scientific and technological research requirements of companies, generally medium-sized, in the sector concerned. Basic technological research (pre-competitive and pre-normative) and the introduction of new technologies in industry constitute their main activities. These organisations may be formal or informal (e.g. consortia) (OECD, 1998b).

Bridging Institutions	
University Interfaces	They directly assist companies in solving technical problems, developing new products and processes, integrating new technologies and training by bringing the company into direct contact with the laboratory or the research unit best placed to respond to the company's needs. Their work consists of various forms of co-operation between companies and research centres, such as ad hoc services, consultancy assignments, joint research programs, and license transfers (Capron and al., 2000).
Vocational Training and Apprenticeship Institutes	Vocational training institutes take care of vocational and technical studies, while apprenticeship institutes provide a dual system of on-the-job training and vocational training.
S&T Parks	They may be defined as *« a project involving a physical space that: (1) involves collaboration within universities, research centres and/or other HEIs; (2) encourages the creation and growth of innovative, technology-based industries, and third-sector companies with high added value, generally located on-site; (3) is run by a permanent team that is actively involved in strengthening the transfer of technology and generating business capacities for the companies using the park »* (definition from the International Association of Scientific Parks).
Incubators & Business Centres	Companies or facilities designed to foster entrepreneurship and help start-up companies, usually technology-related, to grow through the use of shared resources, management expertise, and intellectual capital.
Information Centres	Museums, libraries, statistical offices, database providers, archives, patent records, etc.
S&T Awareness Centres	They aim at supporting public access to technology, science museums, science awakening.

Venture Capital Organisations	
Risk Capital, Start-Up and Seed Money Funding Organisations	It consists mainly in Founders, Friends, Family (FFF) and local funds (e.g. *Fonds Cigale* in France). We find these actors at the very beginning of the development process (i.e. seed and start-up). These investors assume a high level of risks.
Business Angels	An individual who provides capital to one or more start-up companies. The individual is usually affluent or has a personal stake in the success of the venture. Such investments are characterized by high levels of risk and a potentially large return on investment.
Venture Capitalists	Wealthy business-people who are willing to take an equity stake in a fledging company in return for money to "start-up". They agree to take some risks because they believe in the project and they expect very profitable returns. We find these actors essentially in the start-up stage of development, and later also in the early-growth stage (Gompers, 2001).
Equity Markets	New companies funded with venture capital are eventually intended to be sold on the initial public offering market (IPO). Indeed, it is at this stage that the private investors and the venture capitalists may expect valuable profits.
Commercial Banks	They provide long-term finance for new types of business ventures. Banks are an important source of start-up financing for a subset of new businesses. However, commercial banks take part of the venture capital process only when the companies are established, meaning that companies that lack substantial tangible assets and have uncertain prospects are unlikely to receive significant bank loans (Gompers, 2001).

Non-Profit Organisations	
Private Non-Profit Organisations	NPIs whose main activity is the production of goods and services for sale at prices designed to recover most or all their costs (e.g. research institutes, clinics, hospitals, etc) (Frascati Manual, 2002).
Public Non-Profit Organisations	Non-Market Non-Profit Institutions controlled and mainly financed by government.
Individuals	This category includes: citizens, students, individual researchers, entrepreneurs, consumers, etc.

Abroad Sector	
Foreign Business Organisations	This group concerns the international extension of preceding institutions.
Foreign Governmental Institutions	This group concerns the international extension of preceding institutions.
Foreign HEIs	This group concerns the international extension of preceding institutions.
Foreign RTOs	This group concerns the international extension of preceding institutions.
Foreign Bridging Institutions	This group concerns the international extension of preceding institutions.
Foreign Venture Capital Organisations	This group concerns the international extension of preceding institutions.
Foreign Non-Profit Organisations	This group concerns the international extension of preceding institutions.
Foreign Individuals	This group concerns the international extension of preceding institutions.

Table A4: Functional Matrix 1 – Federal State, Regions and Communities

	STI SUPPORT																																			
INSTRUMENTS → OBJECTIVES ↓	grants for R&D projects				grants for research on societal issues				support for hiring				support for investment				support for commercial exploitation				support for consultancy services				fiscal incentives				social incentives				risk capital financing			
	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F
CREATIVE CAPACITY																																				
upstream innovative activities																							4,8										5,0	1,9	1,2	
technology acquisition													0,7	0,8	0,5													2,6								
fundamental R&D	10,5	8,3	5,1	3,9	3,3	3,8	1,2					4,7																2,6		3,8	2,4	2,6				
government R&D				10,5				5,3																												
applied R&D	5,0	3,8	2,4	3,9			3,6				4,8																	13,2								
downstream innovative activities	2,7									3,8	2,4		2,7	3,1	1,9			1,9	2,4		2,7	5,4	7,0	0,8												
TRANSFER CAPACITY																																				
knowledge exchanges																																				
technology exchanges																																				
knowledge transfer																																				
technology transfer																					3,3	5,4	4,8													
knowledge networking																																				
technology networking																																				
ABSORPTIVE CAPACITY																																				
receptivity to knowledge																																				
accessibility to knowledge																																				
acquisition of knowledge																																				
distribution of knowledge																																				
updating knowledge																																				
implementation of knowledge																																				
TOTAL	18,2	12,1	7,5	18,4	3,3	3,8	4,8	5,3	0,0	3,8	7,1	4,7	3,3	3,8	2,4	0,0	0,0	1,9	2,4	0,0	6,0	10,8	16,5	0,8	0,0	0,0	0,0	18,4	0,0	3,8	2,4	2,6	5,0	1,9	1,2	0,0

Abbreviations: V = Flemish Community; B = Brussels-Capital Region + French Community; W = Walloon Region + French Community; F = Federal State.

Explicative Note: In the cell at the intersection of Objective "fundamental R&D" and Instrument "grants for R&D projects", one find 10.5% of all Flemish STI policy measures, 8.3% of all Brussels STI policy measures, 5.1% of all Walloon STI policy measures, and 3.9% of all Federal STI policy measures.

Table A4: Functional Matrix 1 – Federal State, Regions and Communities (con't)

	STI SUPPORT																STI DIFFUSION																			
INSTRUMENTS → / OBJECTIVES ↓	risk capital networking				loan mechanisms				guarantee mechanisms				provision of equity				raise STI awareness				support for the diffusion of STI				mobility measures				creation of spin-offs				valorisation of R&D results and competences			
	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F
CREATIVE CAPACITY																																				
upstream innovative activities	3,3	3,8	2,4										1,7	1,9	1,2																					
technology acquisition																																				
fundamental R&D																									0,1	5,9	0,1	0,5	0,7		0,4	0,3	0,7	1,9	0,4	0,3
government R&D																																				
applied R&D					1,7	3,8	2,4																			1,9								1,9		
downstream innovative activities							1,2								1,2														5,5	6,0	6,1		1,3	3,8	1,2	
TRANSFER CAPACITY																																				
knowledge exchanges																		3,8	2,4		3,3															
technology exchanges																																				
knowledge transfer																								5,3												
technology transfer																																				
knowledge networking																																				
technology networking																																				5,3
ABSORPTIVE CAPACITY																																				
receptivity to knowledge																	3,3	3,8	2,4	5,3																
accessibility to knowledge																								2,6												
acquisition of knowledge																																				
distribution of knowledge																								2,6												
updating knowledge																					6,7			5,3												
implementation of knowledge																									0,3		0,2	0,1								
TOTAL	3,3	3,8	2,4	0,0	1,7	3,8	3,6	0,0	0,0	0,0	0,0	0,0	1,7	1,9	2,4	0,0	3,3	7,7	4,8	5,3	10,0	0,0	0,0	15,8	0,5	7,8	0,3	0,7	6,2	6,0	6,4	0,3	2,0	7,6	1,5	5,5

Abbreviations: V = Flemish Community; B = Brussels-Capital Region + French Community; W = Walloon Region + French Community; F = Federal State.

Explicative Note: In the cell at the intersection of Objective "upstream innovative activities" and Instrument "risk capital networking", one find 3.3% of all Flemish STI policy measures, 3.8% of all Brussels STI policy measures, 2.4% of all Walloon STI policy measures, and 0% of all Federal STI policy measures.

Table A4: Functional Matrix 1 – Federal State, regions and Communities (con't)

	STI DIFFUSION								STI FRAMEWORK CONDITIONS																															
INSTRUMENTS → / OBJECTIVES ↓	transfer to industry				support to stimulate collaborations, partnerships, synergies				standards and regulations				intellectual property rights				Entrepreneurship				Education				life-long learning				science base				efficiency of administrative procedure				**TOTAL**			
	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F	V	B	W	F
CREATIVE CAPACITY																																								
upstream innovative activities																		3,8																	2,4		10,0	11,5	11,9	0,0
technology acquisition																5,3																					0,7	0,8	0,5	7,9
fundamental R&D					3,5	7,9	2,5	2,6																													18,8	31,7	12,0	17,6
government R&D																																					0,0	0,0	0,0	15,8
applied R&D					9,3		11,9	2,6																													16,0	11,5	25,0	19,7
downstream innovative activities		0,1			1,7					0,3					2,4				1,2										3,2	3,7	2,3						19,7	28,1	29,2	0,8
TRANSFER CAPACITY																																								
knowledge exchanges																																					3,3	3,8	2,4	0,0
technology exchanges																																					0,0	0,0	0,0	0,0
knowledge transfer					2,3		6,0										3,3															2,6					5,7	0,0	6,0	7,9
technology transfer	2,7	0,1	1,4	1,1						0,3																						2,6					6,0	5,8	6,2	3,7
knowledge networking								2,6																													0,0	0,0	0,0	2,6
technology networking							2,4																														0,0	0,0	2,4	5,3
ABSORPTIVE CAPACITY																																								
receptivity to knowledge																																1,3					3,3	3,8	2,4	6,6
accessibility to knowledge																					1,3	1,4	0,9									1,3					1,3	1,4	0,9	3,9
acquisition of knowledge																																					0,0	0,0	0,0	0,0
distribution of knowledge																					1,3	1,4	0,9														1,3	1,4	0,9	2,6
updating knowledge																																					6,7	0,0	0,0	5,3
implementation of knowledge																	3,3								3,7		0,2	0,1									7,3	0,0	0,4	0,3
TOTAL	2,7	0,2	1,4	1,1	16,9	7,9	22,8	7,9	0,0	0,6	0,0	0,0	0,0	0,0	2,4	5,3	6,7	3,8	1,2	0,0	2,5	2,9	1,8	0,0	3,7	0,0	0,2	0,1	3,2	3,7	2,3	7,9	0,0	0,0	2,4	0,0	100,0	100,0	100,0	100,0

Abbreviations: V = Flemish Community; B = Brussels-Capital Region + French Community; W = Walloon Region + French Community; F = Federal State.

Explicative Note: In the cell at the intersection of Objective "technology transfer" and Instrument "transfer to industry", one find 2.7% of all Flemish STI policy measures, 0.1% of all Brussels STI policy measures, 1.4% of all Walloon STI policy measures, and 1.1% of all Federal STI policy measures.

Table A5: Functional Matrix 4 – Federal State, Regions and Communities

TARGET INSTITUTIONAL ACTOR → / POLICY RECIPIENT ↓	large companies				SMEs				research centres				higher education institutions				individuals				public authorities				abroad				TOTAL			
	V	Bxl	W	F	V	Bxl	W	F	V	Bxl	W	F	V	Bxl	W	F	V	Bxl	W	F	V	Bxl	W	F	V	Bxl	W	F	V	Bxl	W	F
BUSINESS ORGANISATIONS																																
large companies	1,7	2,2	5,4	14,5																									1,7	2,2	5,4	14,5
SMEs					5,0	12,2	27,6	5,5																					5,0	12,2	27,6	5,5
private research centres & competence poles	4,4		1,2		4,4		1,2	0,5			0,7										1,1								10,0	0,0	3,1	0,5
industry & professional associations						5,6																							0,0	5,6	0,0	0,0
consultancy firms																													0,0	0,0	0,0	0,0
GOVERNMENTAL INSTITUTIONS																																
parliament & ministries																													0,0	0,0	0,0	0,0
local & regional authorities																													0,0	0,0	0,0	0,0
advisory bodies																													0,0	0,0	0,0	0,0
regulatory agencies				1,3				1,3				1,3				1,3													0,0	0,0	0,0	5,3
co-ordination support & promotion org.	4,2	2,0	1,2		7,5	2,0	1,2		5,0	2,0		1,3		2,0		1,3	6,7			1,3				1,3					23,3	8,0	2,4	5,3
supra-national organisations																													0,0	0,0	0,0	0,0
HIGHER EDUCATION INST.																																
higher education institutions													2,5	3,0	7,9		0,8	8,8	5,2	9,2									3,3	11,8	13,2	9,2
RESEARCH & TECHNOLOGY ORG.																																
(inter-) university research centres	0,8				0,8				1,7	21,0	8,7	10,6	0,8				6,7	8,0	4,8										10,8	29,0	13,5	10,6
central services and scientific institutions												8,6								2,6									0,0	0,0	0,0	11,2
public and semi-o public research centres			2,4				2,4		3,3		4,5	7,6								2,6	1,7								5,0	0,0	9,2	10,3
international research communities												10,5																	0,0	0,0	0,0	10,5
joint research organisations				2,6			2,4	2,6				2,6																	0,0	0,0	2,4	7,9
BRIDGING INSTITUTIONS																																
university interfaces													3,3	4,0	2,4														3,3	4,0	2,4	0,0
vocational training institutes																													0,0	0,0	0,0	0,0
S&T parks									3,2	2,0	2,3																		3,2	2,0	2,3	0,0
incubators & business centres	1,3		0,6		15,3	8,0	5,4		0,2	2,0	0,7				0,6														16,8	10,0	7,3	0,0
information centres				1,1		4,0	2,4	1,1				1,1				1,1	0,8	1,0	0,6	1,3	5,0			1,1					5,8	5,0	3,0	6,6
S&T awareness centres																	0,8	1,0	0,6	1,3									0,8	1,0	0,6	1,3
VENTURE CAPITAL ORG.																																
risk capital, start up & seed money funding org.					6,7	4,0	2,4																						6,7	4,0	2,4	0,0
business angels					3,3	4,0	2,4																						3,3	4,0	2,4	0,0
venture capitalists																													0,0	0,0	0,0	0,0
equity markets																													0,0	0,0	0,0	0,0
commercial banks																													0,0	0,0	0,0	0,0
NON-PROFIT ORGANISATIONS																																
private non-profit organisations																	0,8	1,2	0,7	1,3									0,8	1,2	0,7	1,3
public non-profit organisations																													0,0	0,0	0,0	0,0
Individuals																			2,4										0,0	0,0	2,4	0,0
TOTAL	12,4	4,2	10,7	19,5	43,1	39,8	47,2	11,1	13,3	27,0	16,9	43,7	6,7	9,0	10,9	3,7	16,7	20,0	14,3	19,7	7,8	0,0	0,0	2,4	0,0	0,0	0,0	0,0	100,0	100,0	100,0	100,0

Abbreviations: V = Flemish Community; Bxl = Brussels-Capital Region + French Community; W = Walloon Region + French Community; F = Federal State.

Explicative Note: Considering the first column “large companies”, one can observe that 12.4% of Flemish STI policy measures are targeted to large companies, though only 1.7% out of 12.4% is directly implemented to them.