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AN INTEGRATED EVALUATION SCHEME OF INNOVATION SYSTEMS FROM AN INSTITUTIONAL PERSPECTIVE

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An integrated evaluation scheme of innovation systems from an institutional perspective[1]

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Abstract:
This paper aims at proposing an original framework for the mapping of innovation systems. The analytical outline is based on the following paradigm: the innovation process has commonly been accepted as a complex system of interactions between different institutions aimed to achieve specific objectives through the efficient implementation of public instruments. More specifically, the objective of this paper consists, in a first step, in identifying and defining these innovation concepts. In a second step, the STI mapping is evaluated by crossing the STI objectives, instruments and institutional actors into four functional matrices that should all together empirically depict the innovation system. In order to strengthen the validity of the approach, an empirical example implemented at the EU-15 level is presented. The approach is based on the respect of the four following criteria: 1) international comparability of results; 2) representativeness of results; 3) measurement issues; and 4) consistency of the approach.

JEL Subject Classification: O31, O38.

Key Words: Innovation Systems, Innovation Objectives, Innovation Governance, Institutional Set-up.

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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 has been widely recognised as a key engine for economic growth, but also as a strategic means to improve other societal challenges (environmental sustainability and social equity). As Lengrand et al. (2002) underline, "its growing importance makes it a core feature of the knowledge-based economy". Within this view, at the Lisbon European Council in March 2000, the European Union set itself an ambitious goal: to become the world's most competitive and dynamic knowledge-based economy by 2010. In order to foster R&D and innovation activities, governments implement a wide range of policy measures. In addition, institutional set-ups are recognised as a key engine to foster organisational co-ordination, competitiveness, and economic growth. Nevertheless, various system failures can occur if the combination of the mechanisms that shape the innovation process are not functioning efficiently (Woolthuis et al., 2005). Furthermore, significant institutional mismatches may coexist with market failures.

The recent literature suggests that an important condition for successful innovation policy is the capability of governments to understand how various policy areas interact and how policies are co-ordinated into a coherent horizontal innovation policy (OECD, 2003). In that respect, the evaluation of STI public initiatives is becoming a key decision support tool that provides policy makers with a better understanding of policy results, allows them to learn 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) stresses "the absence of a well-articulated and verified analytical framework linking institutional arrangements to technological and economic performance".

This paper aims at developing an original framework for the mapping of innovation systems (IS) based on the four following criteria: 1) international comparability of results; 2) representativeness of results; 3) measurement issues; and 4) consistency of the approach. In concrete terms, we first identify and define the components at the core of National Innovation Systems (NIS) by analysing STI public policies at the European level. Then, the institutional STI mapping is evaluated by crossing these identified STI objectives, instruments and institutional actors (i.e. the components of IS) into four functional matrices[3]. These matrices should all together empirically depict the innovation process that may occur at the national level[4].

The paper is organised as follows. A review of the existing literature related to the assessment of IS is presented in Section 2. In order to deepen the methodological basis, available data sources and their characteristics are reviewed in Section 3. The theoretical canvas is then explained and the major components and players engaged in IS are identified and defined in Section 4. In order to strengthen the validity of this approach, an empirical example implemented at the EU-15 level is developed in Section 5. Finally, we conclude in Section 6 and discuss further research in Section 7.

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[3] See Capron and Cincera (2001) for the presentation of an unified framework to assess NIS from an institutional perspective. More specifically, this paper focuses on the implementation process of a knowledge-based policy with the view of identifying the different stages that underlie the government intervention.

[4] This matricial framework could also be easily extended to other spatial levels.

2. Theoretical Background

The concept of IS is an innovative approach which captures the dynamism of economic activities, as well as the central position of institutions within the process (Freeman, 1987; Dosi et al., 1988; Lundvall, 1992; Nelson, 1993; Edquist, 1997). According to 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". Several research scholars have provided a broader definition of IS focusing either on their functional or spatial issues. Still, whatever the level of analysis, or the relevant level of decision-making, the innovation process has commonly been accepted as a complex system of interactions between different institutions aimed at fulfilling some specific objectives through the efficient implementation of public instruments. In particular, the institutional set-up is at the core of the IS literature (see, e.g. Lundvall, 1992; Edquist and Johnson, 1997; Niosi, 2002). Indeed, 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. Furthermore, IS are complex to analyse given the nature of innovation itself. Indeed, innovation is recognised as a "broad and multifaceted concept, covering not only R&D but also many other factors and activities" (EU, 2003). Subsequently, the assessment of innovation performance is quite a challenge. Several theoretical and empirical attempts to classify and compare the efficiency and effectiveness of IS have already been proposed (e.g., Pavitt, 1984; OECD, 1997a; Lundvall, 1998; Carlsson et al., 2002). This existing literature mainly provides typologies of innovation systems themselves (e.g. comparison of NIS, sectoral classification). Yet, only a few authors have attempted to provide a general taxonomy of the whole set of elements that compose IS (see, e.g., Chang and Shih, 2003; Buesa et al., 2004), so that improvements in that area may be of relevant interest. Table 1 provides a representative but non-exhaustive list of various theoretical or empirical proposals for a classification of IS (whatever their level of analysis). Even if research scholars agree on the key aspects of objectives, instruments, and institutions within innovation systems, only a few typologies of IS integrating the whole set of these elements have been proposed so far.

INSERT TABLE 1 ABOUT HERE

3. Data Sources and Methodology

The aim of this paper is to present a framework for the mapping of IS by means of a taxonomy based on the components and actors engaged in IS (i.e. objectives, instruments, and institutions). Nonetheless, in order to assess IS, an important step is to first consider the available information. Indeed, an evaluation framework designed theoretically, but that may not be verified empirically, would be only moderately valuable. In that matter, we decide to carry out a bottom-up approach which consists in firstly collecting the information before drawing the analytical outline. Various data sources are available to evaluate S&T performance (Table 2). For instance, patent and publication indicators are easily available, especially on a national scale. Yet, STI indicators which are traditionally used to carry out STI policy evaluation (e.g. GERD, BERD, S&T personnel, patents) are not always fully adequate to assess the efficiency and effectiveness of IS. These indicators are very interesting in order to provide a global picture of national STI performance. But, more accurate STI policy-related indicators and their evolution over time, may be needed to truly understand the scope of STI public interventions.

INSERT TABLE 2 ABOUT HERE

The suggested analytical outline is based on the building of four functional matrices (Capron and Cincera, 2001) which are constructed by crossing objectives, instruments, and institutional actors that characterise IS (these generic terms are defined in the taxonomy here below).

- Functional Matrix 1: the objectives-instruments matrix, which describes the links between the STI objectives and the instruments used to fulfil these objectives;
- Functional Matrix 2: the institutions-instruments matrix, which establishes the links between the instruments and the target institutions;
- Functional Matrix 3: the institutions-objectives matrix, which illustrates the main functions managed by the target institutions;
- Functional Matrix 4: the institutional interactions matrix, which tries to identify the inter-connections between institutions playing a predominant role in the IS and the final target institutions.

In order to demonstrate the potential of this approach, these matrices are built at the European level and discussed in Section 5[5].

The major constraint in the building of this set of functional matrices rests in the type of information to be used in order to fill them in. Indeed, as pointed out earlier, it is crucial to design a theoretical canvas that may be empirically verified. Given that issue, we decide to consider the policy program as the central unit of observation in the building of the functional matrices. According to Georghiou and Roessner (2000), "this is the easiest territory for evaluators in that a program almost by definition has boundaries in space and time and certainly should have objectives". Fortunately, the innovation policy database recorded in the European Trend Chart on Innovation provides valuable information on the national policy measures implemented in the various EU-25 Member States. The EU Trend Chart innovation policy database classifies these national measures according to 18 innovation objectives[6]. The countries are responsible for the good representativeness of their list of national innovation policy measures. Yet, if we do not assume the exhaustiveness of this policy database, the information indirectly reflects the sensitivity of EU countries to S&T policy.

With the purpose of identifying all the components of IS, we analyse each single policy action in order to pinpoint the major challenges of this measure (i.e. objectives), how it is implemented (i.e. instruments) and towards which actors it is targeted (i.e. institutions). Note that a policy measure may not fully enter into the range of only one objective, and/or instrument, and/or target institution. Therefore, several objectives, instruments, and/or institutions might be registered for a given policy action.

In a first step, we carry out this bottom-up approach only for the Belgian STI policy measures. To be as comprehensive as possible, we use two different data sources: The Innovation policy database provided by the European Trend Chart on Innovation; and The Belgian Report on Science, Technology and Innovation (OSTC, 2001). The merging of these two documents is aimed at providing the most representative list of STI initiatives in Belgium

[5] Except for functional matrix 4 which needs further research.

[6] I.1 Education & Training ; I.2 Mobility students/researchers/teachers ; I.3 Raising public awareness ; I.4 Innovation & Management ; I.5 Public authorities ; I.6 Promotion of clustering and co-operation of innovation ; II.1 Competition ; II.2 Protection of IPR ; II.3 Administrative simplification ; II.4 Legal and regulatory environment ; II.5 Financing ; II.6 Taxation ; III.1 Strategic vision of R&D ; III.2 Strengthening company research ; III.3 Start-up of technology-based companies ; III.4 Co-operation research/universities/companies ; III.5 Absorption of technologies by SMEs ; IV.1 Other objectives.

occurring at all spatial levels (community, regional and federal[7]). Once all Belgian STI measures have been identified, the next step consists in allocating to each policy one or several STI objective(s), instrument(s), and final target institution(s). Subsequently, we identify various elements that compose the building blocks of the Belgian innovation system, namely the public instruments implemented in order to achieve specific objectives through the action of efficient institutional actors. Each of these components may be subdivided into more detailed categories, which are also composed of more detailed elements. In short, this three-dimensional innovation taxonomy is harmonised with the available policy-related information.

In a second step, in order to strengthen the validity of the taxonomy derived from the Belgian exercise, we perform the same exercise with the STI initiatives that are implemented across the EU-15 countries. For that purpose, we use the policy database provided by the European Trend Chart on Innovation. In a same vein, we attempt to allocate for all EU-15 national STI actions one or several STI objective(s), instrument(s), and final target institution(s) primarily identified here before. This process requires all national STI actions to be reviewed one by one. Indeed, in order to be as close as possible to reality in the reallocation of attributes, a thorough analysis is necessary for each STI action. Gradually, by analysing each national policy measure recorded at European level, some new elements might come forward to complete the innovation taxonomy, the denomination of some other elements might be improved, and the scope of others might be enlarged or narrowed. The purpose is to obtain a harmonised nomenclature that makes possible to classify all institutions of each country according to their policy profile.

At the end of this process, we identify the main STI objectives (18), STI instruments (28), and institutional actors (8) that shape the innovation process. These taxonomical categories correspond to the basic information that we are able to find in each EU-15 country. Despite geographical, historical, economical and cultural specificities, a classification of all EU-15 STI policy measures has been performed according to the elements of the constructed taxonomy. The purpose of the next section is to present this three-dimensional innovation taxonomy.

4. Taxonomy: The Components of IS

As discussed before, the three-dimensional innovation taxonomy developed in this paper is based on the paradigm which views the innovation process as a complex system of interactions between different institutions aimed at fulfilling some specific objectives through the efficient implementation of public instruments. Each of these components may be subdivided into more disaggregated categories, which are also composed of more detailed elements.

4.1. Objectives of IS

For decades, knowledge has been commonly accepted as being the key engine of economic and welfare growth, so that it is at the core of IS. Therefore, it is of crucial importance for governments to better understand the process of creation, distribution and use of knowledge in order to implement mechanisms that should boost their national innovative capacity (Furman et al., 2002). The OECD (1996) states that "in the knowledge-based economy, the science

[7] Since 1970, Belgium has become a federated country. Policy competences are distributed amongst its various entities: three communities (mainly responsible for scientific, research and education), three regions (applied research, economic affairs and territorial issues) and the federal state (all actions of national interest) (See Capron and Meeusen, 2000, for more details).

system contributes to the key functions of: i) knowledge production (i.e. developing and providing new knowledge); ii) knowledge transmission (i.e. educating and developing human resources); and iii) knowledge transfer (i.e. disseminating knowledge and providing inputs to problem solving)". According to this theoretical background, three generic categories of STI objectives have been identified: creative, transfer, and absorptive capacities (Table 3). These objectives may be referred to as the main characteristics which allow to appreciate the efficiency in the production and exploitation of technology flows at the source of knowledge accumulation[8]. These three generic categories of objectives have been further divided into different sub-objectives (Table 3). The definition and scope of activities embraced by these components, which represent the elements of the taxonomy we propose, have been chosen as to maximise the overlap between the STI policy measures in the database and these components.

INSERT TABLE 3 ABOUT HERE

4.2. Public Instruments for IS

Nowadays, all industrialised 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 is 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".
According to the 'Demsetz (1969) criteria': Policy should be balanced 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 have been defined: STI support measures, STI diffusion mechanisms, and STI framework conditions (Table 4). Here also, these generic categories have been further divided in order to match the different policy measures and the retained sub-categories of instruments as best as possible.

INSERT TABLE 4 ABOUT HERE

One could argue that it is a true challenge to limit the analysis to innovation policies since every public initiative might have an impact on the innovation system (e.g. economic policy). Yet, considering evaluation issues, we believe it is useful to draw a global picture of the major public instruments that may be implemented in IS. Also, since the primary purpose of this paper is to compare and assess the STI policy profile of institutions, a harmonised typology of instruments is needed.

4.3. Institutions in IS

[8] 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 (Capron and Cincera, 1999).

The institutional set-up is at the core of the instrumentation in IS (local, regional or national)[9]. Institutions[10] are in charge of the interventions making instruments operational. There is a myriad of institutions which are expected to ensure the efficiency of IS. 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 (Woolthuis et al., 2005). 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 IS[11]. For that purpose, this paper provides a typology of institutional actors which play a role in the innovation process. Eight institutional categories have been identified: 1) business organisations; 2) government institutions; 3) higher education institutes (HEI); 4) non-profit organisations (NPO); 5) research and technology organisations (RTO); 6) bridging institutions; 7) venture capital organisations; and 8) the abroad sector. Table 5 provides a description of these actors which are directly implicated in the innovation process.

INSERT TABLE 5 ABOUT HERE

Figure 1 gives a synthetic diagram that summarises the taxonomical information developed here above. It shows the path of STI public actions within IS. In a first step, governments decide on a strategy to follow in order to enhance their national or regional innovative capacity. For that purpose, they design a specific STI policy mix in accordance with their economic and technological strengths, weaknesses, opportunities and threats. Yet, public STI governance may be somewhat inefficient if its implementation does not correspond to the governmental initial prospects. Therefore, an assessment of the implementation of the STI policy measures and their related administrative procedure may be relevant. In a second step, the targeted institutional actors assimilate these policy actions in their operational management. At that time, the effectiveness of these measures may be evaluated in order to reveal the actual impact of each STI policy action.

INSERT FIGURE 1 ABOUT HERE

Subsequently, an integrated scheme for evaluating both the efficiency and effectiveness of IS may be helpful for government actions. Indeed, 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

[9] "The IS idea is an institutional conception, by excellence" (Nelson and Nelson, 2002).

[10] "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).

[11] Within this view, a new institutional concept could be introduced: *Policy recipient institutions*. This generic term would be 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 an "active bridge" between the policy issuer (e.g. the government's administrations) and the targeted institutions. In other words, the policy recipient would be the institution that receives the funding linked to the measure directly. The policy recipient institution could redistribute the funding afterwards to the final target institutions. This theoretical concept needs further research.

improving strategy definition, increases the efficiency and effectiveness of policy intervention, and demonstrates the effects of intervention. Yet, three dimensions have to be considered in the analysis of IS: objectives, instruments, and institutions. In order to display what is occurring within IS, the building of the functional matrices aims at combining these three elements into a simpler and more easily implementable working canvas than a three-dimensional framework. Figure 2 attempts to conceptualise the essence of the matrices. They are expected to provide a sound evaluation framework of the STI governance of a country or region.

INSERT FIGURE 2 ABOUT HERE

5. Functional Matrices: An Illustration of EU-15 STI Policies

As pointed out earlier, an evaluation framework theoretically designed, but that may not be empirically verified, would be only moderately valuable. In this paper, we suggest an evaluation framework of the STI performance based on the building of four functional matrices which are constructed by crossing objectives, instruments, and institutional actors that characterise IS (these generic terms are defined in the taxonomy here above). In order to further strengthen this analytical outline and test its consistency, we now continue with an empirical application of this theoretical canvas.

The example presented here consists in illustrating the feasibility of the approach and strengthening the validity of the proposed three-dimensional innovation taxonomy. In short, we first record the European national innovation policies[12]. Then, for each of these measures, we identify their specific objective(s), instrument(s), and institution(s) according to the taxonomy primarily defined[13]. This is a very time-consuming exercise since all 523 policy actions recorded in the EU Trend Chart have to be studied one-by-one in order to determine their characteristics accurately. Each policy measure is given an equal weight in the database (whatever their relevance, quality or financial weight). This allows to analyse the degree of completeness or fragmentation of the European IS in its whole, as well as for each NIS. In addition, for each policy measure, we agree on 'distribution keys' related to its objective(s), instrument(s), and target institutional actor(s). This methodological choice is necessary in order to avoid the double-counting of the policy measure in the matrices, especially if the policy measure is aimed at several objectives; and/or is implemented through different instruments, and/or is targeted to different institutional actors. For the sake of simplicity, we use uniform distribution keys[14]. Ultimately, we evaluate the European institutional mapping in STI by crossing these objectives, instruments and institutions into the first three qualitative functional matrices (Tables 6, 8 and 9).

As a result, the functional matrices depict the distribution of the measures given their related objectives, instruments, and institutions. The data in these matrices are expressed in

[12] Here, we used the policy database provided in the EU Innovation Trend Chart (http://trendchart.cordis.lu/).

[13] A policy measure may not fully enter into the range of only one objective, and/or instrument, and/or target institutions. Therefore, several objectives, instruments, and/or institutions might be registered for a given policy action.

[14] By uniform distribution keys, we mean that if a policy measure is composed of two different instruments, these instruments will both have a weight of 1/2 in the database. In the same vein, if it has three objectives, each objective will have a weight of 1/3. If a measure has two objectives and four instruments, each couple objective-instrument will have a weight of 1/8 (= 1/(2×4)). In reality, a policy measure could be composed of two instruments, which would have, for instance, a weight of 80-20%, and not 50-50%. Yet, it would have been a too heavy process to determine the proper distribution keys to apply for each objective / instrument / institution of all EU-15 measures given there are 523 recorded STI policy actions.

percentage of all national STI measures implemented in the EU-15[15]. It is worth keeping in mind that they tell us nothing about the importance in terms of financial means, as well as on the quality and effectiveness of the measures. Rather, they attempt to show the STI issues prioritised by governments (i.e. STI policy mix). The higher the value of a cell, the more that kind of instrument is exploited by public authorities to achieve that specific objective. However, the results must be interpreted cautiously since, on the one hand, one main STI issue might be addressed through 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. Put differently, the study of these matrices is relevant to get a clearer view on how the European STI policy is organised. A priori the results should vary between either a rather uniform distribution of the STI policies into the cells of the matrices (i.e. policy completeness) or, on the contrary, specialisation of the STI policy into certain specific fields (i.e. policy fragmentation).

Table 6 represents the distribution of all STI policy measures in the EU-15 according to their respective objectives and instruments (i.e. functional matrix 1). From this Table, it appears that the majority of STI public actions are mainly devoted to the creative capacity (59.2% out of the total). The remaining policy measures are distributed between the transfer capacity (16.6%) and the absorptive capacity objectives (23.9%). As emphasised by Capron and Cincera (1999), in order to enhance the efficiency of the creative capacity, high levels of both transfer and absorptive capacities are crucial. Concerning the instruments, governments are likely to implement a large majority of STI policies to boost R&D activities, of which one third are direct support measures (34.8%), one seventh are diffusion mechanisms (15.2%), and one tenth are measures for a healthy STI environment (9.2%).

INSERT TABLE 6 ABOUT HERE

More specifically, Table 7 illustrates the instruments that appear to be particularly frequently used such as for instance, direct grants for R&D projects, fiscal incentives, or support for consultancy services. Whereas direct support measures are widely implemented, it follows that diffusion mechanisms are also largely used (39.1% out of all actions). This type of instrument is used during the whole innovation process, from the creative stage (15.2%) to the transfer stage (13.2%) up to the absorptive stage (10.7%). The category of instruments encompassing the measures for a sound STI framework conditions accounts for 20% of all STI measures in the EU-15. For the most part, these are measures linked to the science base (4.3% out of the total), entrepreneurship (4%), and intellectual property rights (3.4%). Note that a budgetary analysis would help us to perceive the real financial means behind all these policies. Indeed, we analyse percentages which describe the degree of completeness or fragmentation of the European IS. All measures are considered as equivalent. Obviously, this is never the case either in monetary or in human terms[16].

INSERT TABLE 7 ABOUT HERE

The functional matrices tend to show the same results but through different perspectives. Therefore, the same findings as before appear just by reading functional matrices 2 and 3 (Tables 8 and 9). Yet, in these two last tables, the purpose is to highlight the institutional profile of the STI policy mix. Subsequently, it seems that governments target SMEs (39.5%

[15] The policy database available on the European *Trend Chart* provides a static picture of the national policy measures implemented in the European countries at a given time. It is constantly updated. The data collected for this research are from August 2004.

[16] Such an analysis needs further research.

out of all measures are devoted to SMEs) to a large extent. Even if these figures globalise European STI measures, the same trend is observed in all EU-15 nations (with more or less the same intensity)[17]. A reason might be that it is difficult for SMEs to reach a critical research mass, so that subsiding their R&D activities is still of prime importance for all policy makers. In the EU-15, the other categories of institutions targeted by the STI policy measures are, on average, large companies (15.9%), research and technology organisations (15.6%), and higher education institutes (13.4%).

INSERT TABLE 8 ABOUT HERE
INSERT TABLE 9 ABOUT HERE

As discussed earlier, the study of these functional matrices is relevant to appreciate the distribution of the STI policy measures in the EU-15 according to generic STI objectives, instruments and targeted institutional actors. Consequently, the STI profile may then appear on a more theoretical basis as either specialised in some specific fields (i.e. STI policy's fragmentation), or harmonised around all STI challenges (i.e. STI policy's completeness). On average, national governments of EU-15 appear to implement a wide range of STI policy actions. The potential of all global kinds of objectives and instruments seems to be captured, with more or less intensity (Tables 6, 8 and 9). Yet, if we look at detailed categories of objectives and instruments (Table 7), it follows that some are not implemented. This could refer to irrelevant association between objective and instrument. On the contrary, it could also show some areas of policy opportunities[18].

This matricial framework could provide a basis for policy makers to think about new STI strategies. By comparing their STI policy profile to other countries/regions, they may better understand their needs and how to respond to them. Yet, benchmarking STI policies is not a self-obvious process. Indeed, large organisational differences in the management of STI policies, high diversity of cultural patterns, industrial specificity, or technological specialisation have been highlighted as reasons why apparently similar institutions can work differently across countries. Furthermore, the result and impact of a policy measure is highly linked to the whole STI policy. Indeed, Mohnen and Röller (2005) have put forward the existence of complementarity, but also substituability, in innovation policies (depending on the phase of innovation – propensity or intensity – and on the particular pair of compared economic policies). Nevertheless, this analytical framework could provide a relevant starting point for such a policy analysis.

6. Concluding Remarks

The taxonomy presented in this paper aims at representing IS through three different points of view: 1) targeted innovation objectives; 2) implemented innovation public policies; and 3) innovation institutional target actors. The combination of these three different ways of analysis is expected to provide a comprehensive synopsis of the STI governance. Indeed, instead of only focusing on R&D objectives and instruments, this taxonomy also embraces other indirect mechanisms that shape the innovation process (e.g. absorptive capacity,

[17] See Appendix 1 which illustrates functional matrix 3 for Belgium, France, Germany, Italy and the United Kingdom.

[18] For instance, Appendix 1 shows that the transfer capacity objective is largely neglected in the STI policy profile of the EU-15 Member States (except for France). Yet, this objective is considered as essential for linking the "creation" (i.e. creative capacity) and "use" (i.e. absorptive capacity) of technology and know-how (OECD, 1996). If governments understand sources of disparities in their STI policy, they may better respond by designing tailored STI policy measures.

framework conditions). These components of the innovation process are fundamental to achieve an efficient and effective knowledge-driven economy, and thus, it is essential to include them in any analysis of IS. Moreover, the institutional dimension is included in this taxonomy in order to understand the sensitiveness of the innovation actors targeted by the STI policy (i.e. STI instruments implemented). Put differently, it is essential to consider the institutional set-up in the analysis of IS since the efficiency of any STI policy is driven by the degree of responsiveness of the target institutional actors.

Even if this three-dimensional innovation taxonomy is not claimed to be exhaustive, we believe it is likely to systematically embrace the majority of the various linkages that may exist within the innovation process (Capron and Cincera, 2001). Indeed, we systematically look at each STI measure initiated in the various EU-15 countries (as recorded in the Trend Chart). All these policy actions have then been classified according to one or several objective(s), instrument(s), and institution(s) identified in the taxonomy. Therefore, we can consider that this three-dimensional innovation taxonomy allows to classify all public initiatives implemented for enhancing the innovative capacity of a country or a region.

In addition, some discrepancies with other existing innovation taxonomies have also been identified. For instance, the typology of "innovation objectives" as depicted in the European Trend Chart on Innovation in order to classify the various national policy measures from the EU-25 may be compared to our classification of STI instruments, as it has been defined as "a broad concept that contains research and technology policy and overlaps with industrial, environmental, labour and social policies" (Kuhlmann and Edler, 2003). Yet, as pointed out earlier, the three-dimensional approach presented here provides two additional, and critical, dimensions in the analysis of IS: 1) STI objectives and 2) institutional actors which play a role in SI. Subsequently, this emphasises once more that this three-dimensional innovation taxonomy is likely to comprehensively capture the majority of the various linkages that may exist within the innovation process.

Next to this three-dimensional innovation taxonomy, three functional matrices built with the components of IS (i.e. objectives, instruments, and institutions) have been presented. These matrices aim at depicting the STI policy profile of IS by considering the policy program as the central unit of observation. They attempt to represent the distribution of the STI policy mix given their related objectives, instruments, and institutions. This framework could be replicated at other spatial levels (local, regional and national). We developed an application at the EU-15 level to demonstrate the feasibility of the approach. Subsequently, we observed that, in general, the EU-15 Member States distribute all their STI actions among all the cells of the functional matrices. So, governments embrace the whole set of innovation challenges and take actions in all areas. Nevertheless, it still seems that European national governments largely implement direct support measures targeted to SMEs in order to enhance their creative capacity (approximately 20% to 30% of the total of all STI policy measures). Even though this finding stands for EU-15 Member States in general, it is likely that this statement is also true for all nations in particular. Obviously, a budgetary analysis would allow to identify the real means that are released for the implementation of the STI policy measures, and would help to confirm (or not) these findings.

To sum up, comparatively to the other types of classification of IS (Table 1), this framework suggests a harmonised and comprehensive outline to analyse the innovation process in its whole by integrating the key theoretical aspects of objectives, instruments, and institutions. Moreover, it respects the four criteria set at the beginning: 1) international comparability of results by providing a methodological canvas replicable in other countries or regions; 2) representativeness of results with regard to the accuracy of STI policy profiles; 3) measurement issues of the STI mapping addressed through harmonised policy-related information; and 4) consistency of the approach using a three-dimensional innovation taxonomy.

7. Further Research

The innovation taxonomy developed here should be viewed as an initial step of an ambitious research which consists in implementing an integrated evaluation scheme of innovation institutional set-ups through the generation of new STI indicators.

For decades, there has been a growing consensus on the necessity to deepen our understanding of the innovation process and its link with STI governance. Yet, advocating for a uniform evaluation framework of innovation systems is a tough challenge given national / regional specificities, the various existing institutional profiles, and the wide spectrum of STI policies (ranging from the direct support of basic research to more indirect measures aimed at improving the absorptive capacity and the mechanisms of transfer of knowledge and new technologies). Within this view, we suggest a methodological framework for the assessment of IS by crossing policy-related STI objectives, STI instruments and innovation institutional actors (i.e. the components of IS) into four functional matrices that should together empirically depict the innovation process that may occur at different spatial levels. In this paper, we establish the validity and feasibility of this approach. The next step consists in quantifying this set of matrices with STI indicators. The quantitative analysis is expected to help for a better understanding of the relative efficiency and effectiveness of innovation systems, as well as their main strengths and bottlenecks.

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Appendix 1

Table A1. Functional Matrix 3 – Distribution of STI Policy measures in Belgium (%)

Objectives Institutions	Creative Capacity	Transfer Capacity	Absorptive Capacity	Total
Large Companies	15.3	1.5	0.3	17.1
Small and Medium Enterprises	48.6	3.7	2.5	54.8
Higher Education Institutions	8.6	1.1		9.7
Research and Technology Organisations	8.6	3.3		11.9
Public Authorities				
Individuals	2.2		4.3	6.5
Abroad Sector				
Total	83.3	9.5	7.1	100

Note: This table should be read as follows. In Belgium, it appears that 54.8% of all STI policy actions are devoted to support SME's activities, of which 88.7% in order to stimulate their creative objective (48.6% of the total).

Table A2. Functional Matrix 3 – Distribution of STI Policy measures in France (%)

Objectives Institutions	Creative Capacity	Transfer Capacity	Absorptive Capacity	Total
Large Companies	4.2	0.8		5.0
Small and Medium Enterprises	30.6	3.1	3.7	37.4
Higher Education Institutions	1.4	12.6	2.8	16.7
Research and Technology Organisations	10.6	21.0	0.9	32.5
Public Authorities		1.9		1.9
Individuals	2.8		3.7	6.5
Abroad Sector				
Total	49.5	39.4	11.1	100

Note: This table should be read as follows. In France, it appears that 37.4% of all STI policy actions are devoted to support SME's activities, of which 81.8% in order to stimulate their creative objective (30.6% of the total).

Table A3. Functional Matrix 3 – Distribution of STI Policy measures in Germany (%)

Objectives Institutions	Creative Capacity	Transfer Capacity	Absorptive Capacity	Total
Large Companies	8.9	1.9	3.8	14.6
Small and Medium Enterprises	15.1	4.8	6.0	25.9
Higher Education Institutions	8.2	1.1	9.8	19.1
Research and Technology Organisations	10.5	3.7	0.4	14.5
Public Authorities	0.4	0.8	3.1	4.2
Individuals	11.2	0.8	9.6	21.6
Abroad Sector				
Total	54.3	13.0	32.6	100

Note: This table should be read as follows. In Germany, it appears that 25.9% of all STI policy actions are devoted to support SME's activities, of which 58.3% in order to stimulate their creative objective (15.1% of the total).

Table A4. Functional Matrix 3 – Distribution of STI Policy measures in Italy (%)

Objectives Institutions	Creative Capacity	Transfer Capacity	Absorptive Capacity	Total
Large Companies	16.1	0.4	7.3	23.9
Small and Medium Enterprises	23.1	0.4	8.6	32.2
Higher Education Institutions	4.3	0.4	4.7	9.4
Research and Technology Organisations	9.5	0.4	5.6	15.5
Public Authorities	0.5	0.4	8.4	9.4
Individuals	0.9	0.4	7.5	8.8
Abroad Sector	0.9			0.9
Total	55.3	2.6	42.1	100

Note: This table should be read as follows. In Italy, it appears that 32.2% of all STI policy actions are devoted to support SME's activities, of which 71.7% in order to stimulate their creative objective (23.1% of the total).

Table A5. Functional Matrix 3 – Distribution of STI Policy measures in the United Kingdom (%)

Objectives Institutions	Creative Capacity	Transfer Capacity	Absorptive Capacity	Total
Large Companies	7.5	1.6	9.0	18.2
Small and Medium Enterprises	25.9	3.7	11.6	41.2
Higher Education Institutions	7.4	2.0	7.7	17.1
Research and Technology Organisations	3.9	1.2	4.1	9.2
Public Authorities	0.2	0.8	3.1	4.2
Individuals	1.6	0.5	8.1	10.2
Abroad Sector				
Total	46.6	9.7	43.6	100

Note: This table should be read as follows. In the UK, it appears that 41.2% of all STI policy actions are devoted to support SME's activities, of which 62.9% in order stimulate their creative objective (25.9% of the total).

TABLES

Table 1. A Review of Literature - Typologies / Classification of Innovation Systems

Author(s)	Date	Type of IS	Characteristics	Strengths	Limits
Pavitt	1984	Sectoral	Description of sectoral patterns from a technical change perspective. From this description follows a three part taxonomy based on firms: 1) supplier dominated; 2) production intensive; and 3) science based.	Classification of firms from all sectors according to their significant innovations.	Analysis limited to business organisations.
Lundvall	1992	National	Definition of the elements that compose NIS: 1) internal organisation of firms; 2) interfirm relationships; 3) role of the public sector; 4) institutional set-up of the financial sector; and 5) R&D intensity and R&D organisation.	Put a central stress on the institutional structure within NIS.	Focus only on the institutional dimension of such systems. Various institutional profiles across countries. Missing element: education and training system (pp. 14-15).
Nelson	1993	National	Comparative analysis between 15 NIS, from large high-income countries to lower income countries.	All 15 studies unified by a broad consensus on the definitions and concepts: "*national innovation system*", "*system*", and "*national*".	Institutions limited to R&D actors.
OECD	1996	National	Three key functions of the science system in the knowledge-based economy: a) knowledge production; b) knowledge transmission; and c) knowledge transfer.	Generic terms to explain the processes of creation, distribution and use of knowledge.	General description; lack of a detailed typology of these functions.
Amable *et al.*	1997	Social	Description of the sensitive variables in IS regarding to Science, Technology, Industry, Human Resources, Education and Training, and Financing. New concept: *Social System of Innovation*.	Typology of 12 industrialised countries into three main groups according to their performance profiles. The *social* concept is free from spatial issues.	Given evolutionary approaches, comparison of the performance of SSI may be difficult over time since the social and economic context always change and evolve (p. 163).
Carlsson	1997	Technological	Four basic assumptions underlying TIS: 1) the system as a whole is the primary unit of analysis, not its components; 2) the systems are not static, but dynamic; 3) technological opportunities are unlimited, so that it is impossible to identify all possibilities; and 4) there is bounded rationality.	General framework for the analysis of TIS. Emphasis on the interactions between technological players and institutions. Evolutionary dimension.	An innovation system is not only about enhancing technologies, economic growth and profit maximisation. Also, other societal objectives such as environmental sustainability and social equity.
Edquist and Johnson	1997	-	Focus on the central position of institutional set-ups in the innovation system, especially because of interactive and cumulative learning processes.	Clarification of the concept of 'institutions'. Taxonomies of institutions and identification of their five main functions in relation to innovations. Distinction between organisations and institutions.	Theoretical work; need for empirical verification (pp. 60-61).
Capron and Cincera	1999	Regional	Typology of European regions according to their technological intensity.	Distribution of EU-15 regions (except Luxembourg) into five technological clusters.	Technological clustering distributed according to 2 dimensions: 1) creative capacity and 2) labour productivity.
European Commission	2002	National	National innovation policy measures classified according to 18 innovation objectives.	Harmonised classification of innovation policy measures from the various EU-25 Member States. Representative list of national innovation policy measures. Budget indicators for a lot of national policy measures and European Innovation Scoreboard.	Confusion between concepts: certain so-called "objectives" may actually be better identified as instruments (*e.g.* Financing, Taxation). Non-exhaustive list of national innovation policy measures.

Table 1. A Review of Literature - Typologies / Classification of Innovation Systems (continued)

Author(s)	**Date**	**Type of IS**	**Characteristics**	**Strengths**	**Limits**
Niosi	2002	National	Recognition of both inefficiency and ineffectiveness of NIS's institutions. Proposal for a benchmarking approach of NSI.	Examples of indicators (benchmark) of NIS performance in terms of efficiency and effectiveness.	Theoretical work; need for empirical and/or quantitative verification.
Chang and Shih	2003	National	Comparative analysis between two distinct SI (Taiwan and China) by using a framework based on six kinds of functions of generic types of institutions (*i.e.* policy formulation, performing R&D, financing R&D, promotion of HR development, technology bridging, and promotion of technological entrepreneurship), as well as on four types of interactions among these institutions (*i.e.* R&D collaboration, informal interaction, technology diffusion, and personnel mobility).	Analytical framework for studying a single NIS as well as for comparing IS in different countries.	Qualitative description of each institution function and their related interactions. Non-exhaustive framework.
Buesa *et al.*	2004	Regional	Identification of four factors determining RIS: 1) regional and productive environment for innovation; 2) role of universities; 3) role of the civil service; and 4) role of innovative firms.	Multivariate data analysis (*e.g.* factorial analysis, cluster analysis) in order to provide a typology of Spanish regions. Wide range of indicators for each factors determining RIS.	Analysis limited to the Spanish RIS.
Malerba	2004	Sectoral	Descriptive analysis of the differences and similarities in the structure, organisation and boundaries of sectors. Identification of the three main factors affecting innovation as well as the commercial performance and international competitiveness of firms and countries in the different sectors: a) Knowledge and Technologies; b) Actors and Networks; and c) Institutions.	Multidimensional, integrated and dynamic view of sectors (including market and non-market interactions).	"Taxonomies of sectoral systems have to be constructed. Here, comparative work is particularly relevant. These taxonomies should group sectoral systems in terms of elements, structure and dynamics, so that common features among sectors can be identified and a general description of their characteristics can be proposed" (p. 503).

Table 2: Various data sources for STI information

Data source	**Type of data**	**Characteristics**	**Advantages**	**Drawbacks**	**Spatial Coverage**
European Trend Chart on Innovation	Qualitative & Budgetary	Database of national innovation policy measures	Representative list of measures. Policy-related information	Non-exhaustive list	EU-25, Bulgaria, Israel, Norway, Romania, Switzerland, Turkey
BRISTI (OSTC, 2001)	Quantitative, Qualitative & Budgetary	S&T innovation indicators. S&T institutional profile	Representative list of measures. Policy-related information. Regional and community data	Non-exhaustive list	Belgium
Community Innovation Survey	Quantitative & Qualitative	Survey sent to innovative enterprises	National data. Inter-country comparisons	Largely confidential data	EU-25
European Innovation Scoreboard	Quantitative	Table of 22 STI indicators	National data. Inter-country comparisons	Macro-level data	EU-25, USA and Japan
OECD, EUROSTAT, IMF, World Bank, UNESCO, NSF, etc.	Quantitative & Qualitative	International statistics on various topics	National data. Inter-country comparisons	Macro-level data	World

Table 3. Objectives of Innovation Systems

Objective	Definition	Components	Description / Examples
Creative Capacity (knowledge production)	Production of new scientific and technological knowledge as well as activities located upward and downward the innovation process.	Upstream Innovative Activities	Feasibility studies and enhancement for innovation opportunities; creation of start-ups and innovative enterprises that would open up new markets for promising products, processes and services.
		Technology Acquisition**	Technology licensing; acquisition of patent rights, prototypes and design.
		Fundamental R&D	Experimental or theoretical work undertaken primarily to acquire new knowledge, without any particular application or use in view (OECD, 2002). Mainly carried out by higher education institutes.
		Government R&D	R&D activities ordered by public authorities, such as defence R&D or environmental R&D.
		Applied R&D	Investigation undertaken in order to acquire new knowledge, directed primarily towards a specific practical aim or objective (OECD, 2002). Mainly carried out by private organisations and research institutes (public or private).
		Downstream Innovative Activities	Tooling-up and industrial engineering; development of prototypes; design; other capital acquisition; production start-up; marketing for new or improved products; training; software (OECD, 1997b).
Transfer Capacity (knowledge transfer*)	Sphere of the economy aimed to bridge the gap between the creation and the use of technology and know-how.	Knowledge & Technology Exchanges	Informal interactions among the actors that facilitate upstream and downstream linkages on tacit knowledge as forums, scientific conferences or feedback opinions from final users on a product/service, intra-networks between research institutions.
		Knowledge & Technology Transfer**	Formal transfer of know-how and/or technical knowledge from one organisational setting to another; use of technology outputs: patents, licenses, equipment, technical information, related skills to users issued by a party external to the project (Kingsley et al., 1996).
		Knowledge & Technology Networking	"Rich and dynamic phenomenon in which 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" (Skyrme, 1995). The network's members are interconnected.
Absorptive Capacity (knowledge transmission)	"Acquisition and assimilation of information by an organisation as well as the organisation's ability to exploit it. Therefore, an organisation's absorptive capacity does not simply depend on organisation's direct interface with the external environment, but also on transfers of knowledge across and within sub-units that may be quite removed from the original point of entry" (Cohen and Levinthal, 1990).	Receptivity to Knowledge & Technology	Awareness for learning new or existing knowledge/technologies.
		Accessibility to Knowledge & Technology	Well-shaped completeness of education, vocational training and apprenticeship channels. Also, all other socio-economic processes which provide a wide variety of educational and professional tuitions/degrees.
		Acquisition of Knowledge & Technology	Goods and services purchases; reverse engineering; physical capital investment. Directly linked to the infrastructure and the operational functionning of the innovation institutions, but not directly devoted to the innovative activities in themselves.
		Distribution of Knowledge & Technology	Adequacy and quality of the knowledge/technology transmission system (administrative procedure, education system, IPR infrastructure).
		Updating Knowledge & Technology	Capability of learning and applying new skills; diffusion of new knowledge/technology amongst the actors.
		Implementation of Knowledge & Technology	Hiring of HR; mobility; use of new or existing technologies; linkages between education, vocational training and the professional world.

Notes: * 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". The same might be stated with regard to knowledge transfer.
** Technology transfer may occur at each stage of the innovation process, whereas technology acquisition only takes place in the creative phase.

Table 4. Public Instruments for Innovation Systems

Instrument	Definition	Components	Description / Examples
STI Support Measures	"The main financial and fiscal instrument used either in isolation or in combination to stimulate R&D investment", as well as measures elaborated "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" (EC, 2003).	Direct measures	"Direct transfer of financial support from the public to the private sector" (EC, 2003): 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	Mainly fiscal incentives: "The public sector forsakes tax income from the private sector in exchange for approved investment behaviour" (EC, 2003).
		Risk capital measures	Instruments affecting the flow and use of risk capital for innovation-related activities likely to increase R&D levels in the long-term (typically encourage investment in spin-offs, start-ups and new-technology based firms).
		Loan mechanisms	Participative loans, restructuring financial loans, subsidies on the interest rate, etc.
		Guarantee mechanisms	Bank credit guarantee, public guarantee for equity investment, guaranteed loans for investments, etc.
		Provision of equity	Supply of equity (local and regional) in order to help growing or new businesses.
STI Diffusion Mechanisms	Infrastructure that encourages a rapid spread of awareness and knowledge of innovation. It concerns "both expansion and relocation of knowledge" (Park, 1999).	Raise STI awareness	Public awareness and acceptance of STI; enhance consumer demand for technological novelty; etc.
		Support for STI diffusion	Promotion and use of new product/process/service among institutions; experts share/learn other technology development proceedings with firm managers.
		Mobility measures	Students/research workers/engineers/scientists; from one country/region or industrial sector to another; from education or research institutes to industry, and vice-versa.
		Creation of spin-offs	Assist graduates/researchers in establishing their own business, particularly on-campus site.
		Valorisation of R&D results and competences	In order to help in the commercial exploitation of R&D results and competences.
		Transfer to industry	Industry adoption of new technologies and diffusion through capital equipment (OECD, 1998a).
		Support to stimulate collaborations and partnerships	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, 1998a).
STI Framework Conditions	Major condition for the successful implementation of STI policies. 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.	Standards & 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 (EC, 2003).
		IPR infrastructure	Harmonisation of IPR system; reducing complexity/costs associated with patenting and the maintenance of patents; hastening the formulation and adoption of standardised patent criteria and rules of legal protection; etc (EC, 2003).
		Entrepreneurship	In order to stimulate the launching of new SMEs, start-ups, spin-offs, and NTBFs.
		Education policy	Availability of an educated and properly qualified working force.
		Life-long learning	Continuing -, vocational -, on-the-job -, distance learning; apprenticeship; seminars; 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	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 macro-economic conditions, sustainable development, competition and the general fiscal environment.

Table 5. Innovation Institutional Actors within Innovation Systems

Institutional Actor	Definition & Components	Examples
Business Organisations	It includes (OECD, 2002): 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.	Large Companies; Small and Medium Enterprises; Private Research Centres & Competence Poles; Industry & Professional Associations; and Consultancy Firms.
Government Policy Institutions	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 design, implement, and administer the economic and social policy of the community (OECD, 2002).	Parliament & Ministries; Local & Regional Authorities; Co-ordination Support & Promotion Organisations; Advisory Bodies; Regulatory Agencies; Supra-National Institutions.
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. 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.	(Inter-)University Research Centres; Autonomous university research centres; Central Services and Scientific Institutions (Gill, 2002); Public and Semi-Public Research Centres; International Research Communities; and Joint Research Organisations (OECD, 1998*b*).
Bridging Institutions	They are mainly composed of 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).	University Interfaces; Vocational Training and Apprenticeship Institutes; S&T Parks; Incubators & Business Centres; Information Centres; and S&T Awareness Centres.
Venture Capital Organisations	This category includes the different institutional actors which 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. It is worth reporting that VC not only finances high technology industry, but also low technology industry (Zider, 1998).	Five broad categories of VC actors (Gompers and Lerner): Risk Capital, Start-Up and Seed Money Funding Organisations; Business Angels; Venture Capitalists; Equity Markets; and Commercial Banks.
Non-Profit Organisations	This sector includes (OECD, 2002): 1) non-market non-profit institutions controlled and mainly financed by government; 2) private non-profit institutions serving households (i.e. the general public) whose main activity is the production of goods and services for sale at prices designed to recover most or all their costs; and 3) private individuals or households.	1) General public; 2) Research institutes, clinics, hospitals; 3) citizens, individual researchers, entrepreneurs, students, consumers.
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).	

Table 6. Functional Matrix 1 – Distribution of EU-15 STI Policy Measures among the different components of objectives and instruments (% of all EU-15 measures)

Instruments Objectives	STI Direct Support Measures	STI Diffusion Mechanisms	STI Framework Conditions	Total
Creative Capacity	34.8	15.2	9.2	59.2
Transfer Capacity	1.7	13.2	1.7	16.6
Absorptive Capacity	4.1	10.7	9.2	23.9
Total	40.6	39.1	20.1	100

Note: This matrix has to be understood as follows: in the EU-15, an average of 34.8% of all STI measures appears to be direct support instruments implemented to enhance national creative capacity.

Table 7. Functional Matrix 1 – Distribution of EU-15 STI Policy Measures among the different components of objectives and instruments (% of all EU-15 measures)

Objectives / Instruments	STI DIRECT SUPPORT MEASURES														STI DIFFUSION MEACHANISMS								STI FRAMEWORK CONDITIONS									TOTAL
	Direct grants for R&D projects	Subsidies for research on societal issues	Public technology procurement	Subsidies for commercial exploitation	Support for consultancy services	Subsidies for hiring	Subsidies for R&D investment	Fiscal incentives	Loan mechanisms	Guarantee mechanisms	Provision of equity	Risk capital financing measures	Risk capital networking measures	**Sub-total**	Support for the diffusion of STI	Raise STI awareness	Mobility of researchers	Creation of spin-off	Valorisation of R&D results and competences	Transfer to industry	Support to stimulate collaborations	**Sub-total**	Standards & regulations	Protection of IPR	Entrepreneurship	Education	Life-long learning	Science base	Favourable economic environment	Administrative procedure	**Sub-total**	
CREATIVE CAPACITY																																
Upstream innovative activities	0.29			0.35	1.91	0.09	0.70	0.79	1.20	1.21	1.49	4.54	0.88	13.44	0.27	0.18		0.12	0.27	0.14	0.83	1.81			2.26			0.36	1.17	0.53	4.32	19.58
Technology acquisition	0.03				0.18		0.35	0.35		0.18				1.08	0.09						0.39	0.48		0.89				0.18	0.05	0.05	1.16	2.72
Fundamental R&D	1.47	0.22				0.09	0.34							2.12		0.05	0.18	0.03	0.03		0.32	0.60		0.02			0.02	0.09	0.03		0.17	2.88
Government R&D	0.64					0.18	0.26							1.07			0.18					0.18		0.02			0.02	0.27			0.32	1.56
Applied R&D	5.31	1.71	0.18		0.25	0.82	0.50	2.45	0.85	0.15	0.09	0.26		12.55	0.05	0.23	0.85	0.06	0.26	0.03	5.74	7.21			0.15			0.54	0.39	0.41	1.49	21.25
Downstream innovative activities	0.50			0.44	1.16	0.35	0.35	0.09	0.55	0.18	0.18	0.53	0.18	4.49		0.64		2.27	1.42	0.03	0.56	4.91		1.16	0.12			0.36	0.08	0.05	1.76	11.17
Sub-total	8.23	1.93	0.18	0.79	3.50	1.52	2.50	3.68	2.60	1.71	1.75	5.33	1.05	34.75	0.41	1.09	1.21	2.48	1.98	0.20	7.84	15.20	0.00	2.09	2.53	0.00	0.05	1.81	1.72	1.02	9.21	**59.16**
TRANSFER CAPACITY																																
Knowledge exchanges					0.13								0.09	0.22	0.83	0.18			0.09		0.23	1.33						0.55			0.55	2.10
Technology exchanges				0.09										0.09					0.09			0.09									0.00	0.18
Knowledge transfer	0.27				0.24									0.50	0.25	0.18	0.09		0.28	0.09	0.43	1.32		0.18			0.09	0.18			0.46	2.28
Technology transfer	0.18				0.44	0.09			0.09					0.80		0.83	0.06	0.25	0.09	1.76	0.49	3.47		0.37							0.37	4.64
Knowledge networking	0.04										0.09			0.13			0.37			0.05	1.01	1.42						0.09			0.09	1.65
Technology networking														0.00				0.03	0.60	0.23	4.72	5.57			0.03			0.18			0.21	5.79
Sub-total	0.49	0.00	0.00	0.09	0.81	0.09	0.00	0.00	0.09	0.00	0.09	0.00	0.09	1.74	1.07	1.19	0.52	0.28	1.15	2.12	6.88	13.21	0.00	0.55	0.03	0.00	0.09	1.01	0.00	0.00	1.68	**16.63**
ABSORPTIVE CAPACITY																																
Receptivity to knowledge	0.17													0.17	3.62	0.09					0.09	3.80		0.36	0.27						0.63	4.60
Acquisition of knowledge														0.00	0.18	0.09						0.27		0.09	0.18	0.36	0.15	0.18		0.99	1.94	2.21
Accessibility to knowledge							0.61							0.61								0.00						0.09			0.09	0.70
Distribution of knowledge					0.30		0.09						0.17	0.56	0.45	0.63	0.18				0.13	1.39	0.18	0.18	0.36	0.31	1.18	1.03	0.18	0.18	3.61	5.56
Updating knowledge	0.06	0.26		0.09	0.32	0.26			0.06					1.04	0.18	2.47					0.09	2.74	0.18		0.09	0.18	0.81	0.18		0.18	1.62	5.39
Implementation of knowledge						1.59		0.09						1.68	0.09	0.54	1.31				0.57	2.51		0.09	0.54		0.71				1.34	5.53
Sub-total	0.23	0.26	0.00	0.09	0.62	1.85	0.69	0.09	0.06	0.00	0.00	0.00	0.17	4.06	4.52	3.81	1.49	0.00	0.00	0.00	0.88	10.71	0.36	0.72	1.44	0.85	2.85	1.48	0.18	1.35	9.23	**23.99**
TOTAL	8.95	2.19	0.18	0.96	4.93	3.46	3.19	3.77	2.74	1.71	1.84	5.33	1.31	**40.56**	6.00	6.10	3.22	2.75	3.13	2.32	15.60	**39.12**	0.36	3.36	3.99	0.85	2.99	4.29	1.89	2.37	**20.11**	**100**

Notes: This functional matrix should be read as follows. The numbers in the cells are percentages. They represent the global distribution of all STI policy measures implemented in EU-15 according to the objectives and instruments from each single measure (see methodology). For instance, on average 8.9% out of all measures implemented in the EU-15 Member States are ‘grants for R&D projects’, of which 90% concerns the objective of creative capacity (8.2% of the total).

If a cell is empty, it means that no measure has been recorded which targets the specific instrument in column in order to respond to the given objective in line.

On the contrary, when a value 0.00 is registered, it implies that a public action actually occur, but that the percentage referring to it is very small compared to the other types of STI policies implemented in the EU-15 countries (the value is lower than 0.01).

Table 8. Functional Matrix 2 – Distribution of EU-15 STI Policy Measures among the different components of instruments and institutions (% of all EU-15 measures)

Instruments / Institutions	STI Direct Support Measures	STI Diffusion Mechanisms	STI Framework Conditions	Total
Large Companies	7.4	5.5	3.1	15.9
Small and Medium Enterprises	22.3	11.0	6.2	39.5
Higher Education Institutions	2.8	7.5	3.2	13.4
Research and Technology Organisations	4.4	8.3	2.9	15.6
Public Authorities	0.1	1.8	1.2	3.1
Individuals	3.6	4.5	3.6	11.6
Abroad Sector	0.1	0.6	0.0	0.7
Total	40.6	39.1	20.1	100

Note: This matrix should be read as follows. In the EU-15, it appears that 39.5% of all STI policy actions are devoted to support SME's activities, of which 56.4% through STI direct support measures (22.3% of the total).

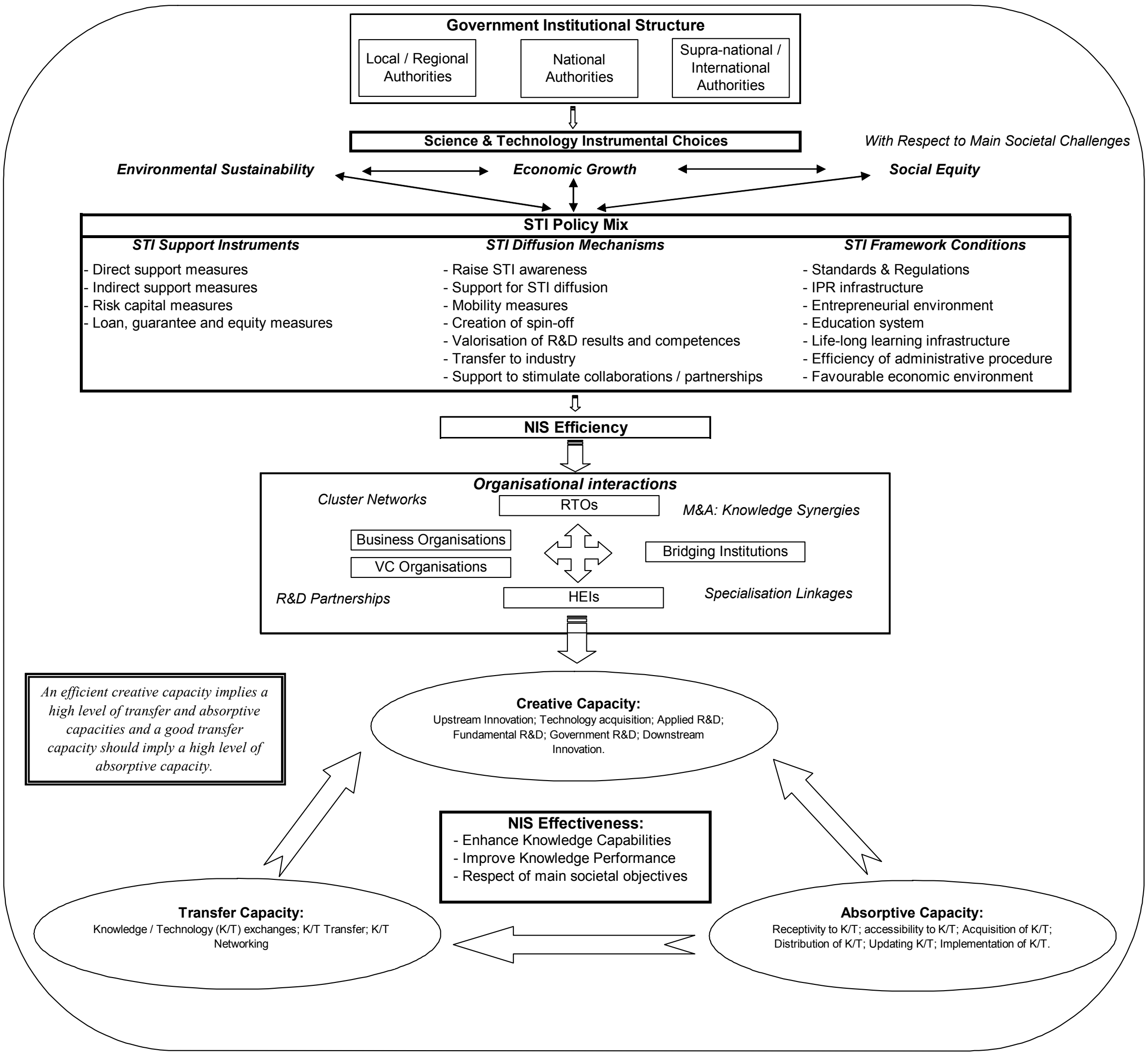
Table 9. Functional Matrix 3 – Distribution of EU-15 STI Policy Measures among the different components of objectives and institutions (% of all EU-15 measures)

Objectives / Institutions	Creative Capacity	Transfer Capacity	Absorptive Capacity	Total
Large Companies	9.9	2.2	3.8	15.9
Small and Medium Enterprises	27.8	4.7	7.0	39.5
Higher Education Institutions	6.7	3.5	3.2	13.4
Research and Technology Organisations	8.5	4.9	2.2	15.6
Public Authorities	0.4	0.6	2.1	3.1
Individuals	5.6	0.4	5.6	11.6
Abroad Sector	0.3	0.4	0.0	0.7
Total	59.2	16.6	23.9	100

Note: This matrix should be read as follows. In the EU-15, it appears that 39.5% of all STI policy actions are devoted to support SME's activities, of which 70.4% in order to stimulate the creative objective (27.8% of the total).

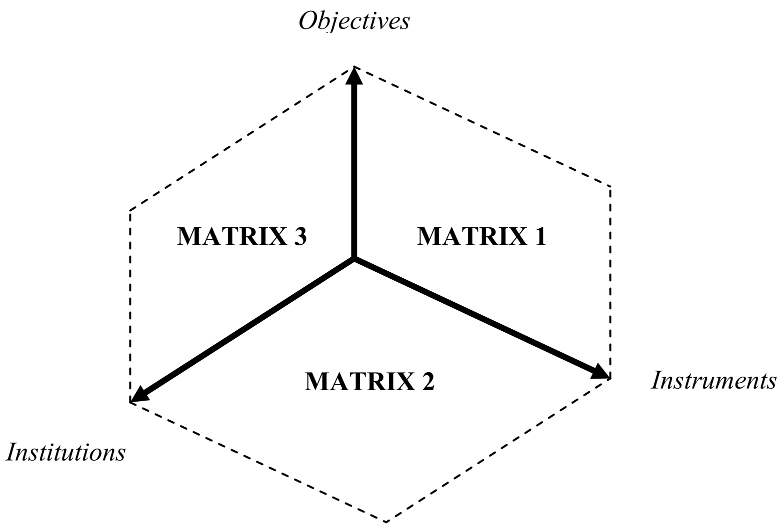
FIGURES

Figure 1. The STI Governance



Source : Adapted from Capron and Cincera (2001).

Figure 2. Conception of the Functional Matrices



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