Innovation Policies From the European Union: Methods for Classification

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This study focuses on taxonomic and typological methods of innovation policies in the European institutional context. Although many types of policies affect innovation, no universally accepted criteria exist to classify them. As innovation policy in a myriad of thematic areas—systemic model—has become pluralized, this article offers a method for classification. Such policies are grouped and categorized according to biological and neofunctional approaches.

Keywords: *innovation system; innovation model; innovation policy; European Union; taxonomy; typology*

Introduction

Innovation policy—as a generic policy—is a set of actions intended to raise the quantity and efficiency of innovative activities. In turn, innovative activities are the creation, adaptation, and adoption of new products, processes, or services (European Commission, 2000a).

Although research is a source of innovation, this encompasses more than a successful application of research results. Because it is through enterprise that economic benefit of the successful exploitation of novelty is captured, enterprise is at the heart of the innovation process. Thus, innovation policies must extend their focus beyond the link with research and have the ultimate effect on enterprise (European Commission, 2003).

Innovation is broadly defined to include not only putting new technological inventions into practice but also carrying out any new combination of productive resources that amounts to the setting of new production (Schumpeter, 1939). Thus, this Schumpeterian definition of the term *innovation* includes the development of new consumer goods, new methods of production, new markets, and new forms of industrial organization.

A broader and more integrated policy framework built on the concept of an enlarged European research area emerged in 2000 (European Commission, 2000b). In this context, a spectrum of innovation policy scenarios was envisaged from centralization to decentralization (Kuhlmann, 2001).

The architecture of the European Union (EU) for innovation is multidimensional—supranational policy furniture juxtaposed with national, regional (Braczyk, Cooke, & Heidenreich, 1998; Ohmae, 1993), sectoral (Breschi & Malerba, 1997; Cooke, Gomez Uranga, & Etxebarria, 1997; Malerba, 2002), and technological (Carlsson, 1995, 1997; Carlsson & Stankiewicz, 1991) policy artifacts.

As innovation policy in a myriad of thematic areas—systemic model—at the EU level became pluralized, we faced the cognitive challenge of putting them into some form of recognizable order. Thus, a system of classification is used to group and categorize EU innovation policies according to a biological and neofunctional approach.

Substantial academic effort has been devoted to systemic models of innovation (Edquist, 1997, 2001; Edquist & Johnson, 1997; Lundvall, 1992; Lundvall, Johnson, Andersen, & Dalum, 2002; Nelson, 1993). However, there has been relatively little analysis of the taxonomy

AUTHORS' NOTE: The authors are deeply grateful to Nicholas Neill-Fraser for helpful comments on an earlier version of this article. Acknowledgment is made to Barry Bozeman, Mark Dodgson, Stefan Kuhlmann, Ruud Smits, and the Pew Center on Global Climate Change for their permission to reproduce their tables. Special thanks are given to participants in the TNO-IPg Strategy Day for their remarkable observations in Delft on 2 July 2007. This study was conducted under the umbrella of TNO-IPg Long Term Research Program Renewal of Innovation: Knowledge Investment Projects "Innovation Policy Monitoring and Impact" No. 13-001 KIP 07-002.

Bulletin of Science, Technology & Society Vol. 27, No. 6, December 2007, 467-481
DOI: 10.1177/0270467607308287
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or typology of innovation policies (Alic, 2002; Alic, Mowery, & Rubin, 2003; den Hertog & de Groot, 2005) and a scarcity at the EU level (Kuhlmann, 2002; Lundvall & Borrás, 2005; Rothwell & Dodgson, 1992; Smits & Kuhlmann, 2002).

Although many types of policies affect innovation, no universally accepted criteria classify them. Taxonomy or typology of innovation policies seldom includes regulatory policies, such as environmental or competition regulation. Regulatory policies can strongly influence innovation. The environmental literature (e.g., Blind et al., 2004; Jaffe, Newell, & Stavins, 2003; SQW, 2006) includes many studies of regulation-induced innovation, such as the development of greenhouse gas emission controls. Likewise, energy policy also has affected innovation. For example, efficiency standards have reduced the average energy consumption of household appliances (e.g., Rubin, 2001). In addition, competition policy is recognized as shaping innovation (e.g., Hart, 2001).

All in all, this study focuses on taxonomic and typological methods of innovation policies in the institutional context of the EU. The article is organized as follows. To begin with, innovation per se, models of innovation, and innovation policy are discussed. In Section 3, the EU policy and regulation process are briefly described. In Section 4, data and methodology used for the taxonomy and typology of innovation policy are specified. In Section 5, the resulting taxa and types of the EU policies on innovation are shown. In Section 6, models on innovation policies are depicted. Before concluding, science, technology, and innovation policies are examined. Finally, some concluding remarks are given.

Theoretical Framework

In this section, we define the constructs needed for a taxonomy and typology and thereby the scope for this study. At the outset, innovation is the successful production, assimilation, and exploitation of novelty in the economic and social spheres. In a more detailed way, innovation is the renewal and enlargement of the range of products and services and the associated markets; the establishment of new methods of production, supply, and distribution; and the introduction of changes in management, work organization, and the working conditions and skills of the workforce (European Commission, 1995).

Regarding innovation theories, the linear models study innovation as a process divided into different stages (Rogers, 1995). In contrast, systemic models (Edquist, 1997, 2001; Edquist & Johnson, 1997; Lundvall, 1992; Lundvall et al., 2002; Nelson, 1993) conceive innovation as a complex process involving different actors and their interactions.

Systems strive to achieve goals for which their elements fulfill specific functions. Different typologies of system functions have been developed with different degrees of detail and emphasis (Johnson, 2001). A general typology of innovation system functions set out three categories, namely, reduction of uncertainty, management of conflict and cooperation, and provision of incentives (Edquist & Johnson, 1997).

Once the model is chosen, innovation policies can be devised. Although there is a lack of consensus on the definition of public policy, Birkland (2001) indicates elements common to all definitions of public policy: The policy is made in the name of the "public"; policy is generally made or initiated by government; policy is interpreted and implemented by public and private actors; policy is what the government intends to do.

Regarding the theoretical framework of policy instruments, Lascoumes and Le Gales (2007) present two arguments. Firstly, public policy instrumentation is a major issue in public policy, as it reveals a theorization of the relationship between the governing and the governed: Every instrument constitutes a condensed form of knowledge about social control and ways of exercising it. Secondly, instruments are not neutral devices: They produce specific effects, independently of the objective pursued (the aims ascribed to them), which structure public policy according to their own logic.

Public policy instrumentation means the set of problems posed by the choice and use of instruments (techniques, methods of operation, devices) that allow government policy to be made material and operational. Another way of formulating the issue is to say that it involves not only understanding the reasons that drive towards retaining one instrument rather than another but also envisaging the effects produced by these choices. By way of indication, a brief catalogue of these instruments can be drawn up: legislative and regulatory, economic and fiscal, agreement- and incentive-based, information- and communication-based. But observation shows that it is exceptional for a policy, or even a program for action within a policy, to be monoinstrumental. Most often, the literature notes a plurality of instruments being mobilized and then raises the question of coordinating them (Bernelmans-Videc, Rist, & Vedung, 1998).

Apart from national governments, nongovernmental organizations, public-private partnerships, subnational agencies, and supranational programs all promote innovation policies as well. In this study, we only focus on

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the EU innovation policies. Institutionally, innovation policies at the EU level must follow the principles of *subsidiarity* and *European added value*. The first rule means that those policies have to be justified through supranational formulation that would not be effectively managed by the member states, while the second principle requires from such policies a synergy effect not attainable within the national borders.

The European Council (2000) in Lisbon applied the open method of coordination (OMC) to innovation policies, introduced in the Employment Strategy of the Amsterdam Treaty. The European Convention (2002) decided not to codify the OMC within the European Constitution but recognized the special logic of innovation policies by drafting a separate subarticle (Kaiser & Prange, 2004).

Innovation policies in the EU are multifaceted, ingrained, and wide ranging, including all initiatives regarding science, education, research, technology development, and industrial modernization, overlapping also with industrial, environmental, labor, and social policies (Shapira & Klein, 2001). In fact, due to the complexity of the innovation policy system at the EU level, a need of a typology arises. The epistemic strategy is to categorize EU innovation policies in line with two perspectives: biological and neofunctionalist.

First, we use biological heuristics, a method by which species of organisms are classified, because we consider the criteria useful for the purpose of our study. Modern classification in biology has its root in the work of Linnaeus, who grouped species according to shared physical characteristics. These groupings have since been revised by molecular systematics, which uses DNA sequences as data (Simpson, 2006).

Second, from a neofunctionalist standpoint, European integration has brought a multilayered division of labor to classical nation-state functions. In these circumstances, innovation systems are stirred up by the increasing socioeconomic and political Europeanization since the 1980s. Nonetheless, EU innovation policies are still pursued in parallel on the supranational, national, and subnational levels. The justification for multiple but separate innovation policies at the EU level has been overtaken by changed circumstances (Georghiou, 2001).

EU Policies and Regulations

In this section, we concisely depict the EU architecture for producing policies and regulations. Under the EU governance system, policies are defined as expected outcomes of the EU work and provide a framework within which the EU operates. Regulations are the procedures that define how the EU will fulfill the goals defined in the policies. They also may clarify policies or state law. The EU governance relies on the method that arbitrates between different interests by two filters, namely, the general interest at the level of the Commission and democratic representation at the level of the Council and the Parliament. Innovation policies fall into the scope of the codecision procedure.

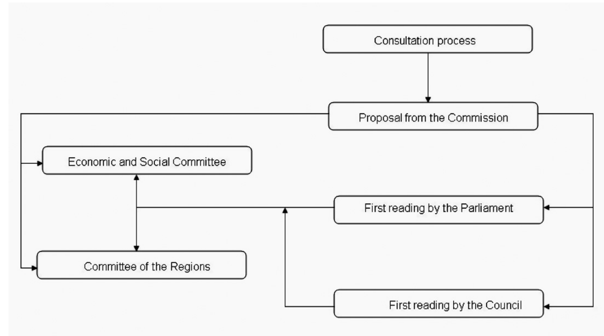

Figure 1. Early Stage of the Codecision Procedure

The Commission alone proposes policies and regulations. Besides that, the Commission has the ability to execute policy. Regulatory and budgetary acts are adopted by the Council, representing the member states, and the Parliament, representing citizens (European Commission, 2001). Central to the EU's decision-making system is the codecision procedure. This sets the principle of parity and means where neither the Parliament nor the Council may adopt legislation without the other's assent.

The Commission has a monopoly of legislative initiative in all the areas that are subject to the codecision procedure. Innovation is among them. The Commission's proposal is the result of an extensive consultation process (see Figure 1), which may be conducted in various ways, namely, impact assessment, reports by technical or scientific experts, consultation of national experts, international organizations or nongovernmental organizations, consultation via green and white papers, and so on. The work of European contract research organizations such as TNO, Fraunhofer ISI, or VTT plays a role in this phase.

A consultation process is also launched among the different Commission departments in order to ensure that all aspects of the matter in question are taken into account (interservice consultation). The Commission's proposal is adopted by the College of Commissioners on the basis of either a written procedure (no discussion among Commissioners) or an oral procedure (the dossier

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Table 1. Frequency Distribution of EU Documents on Innovation

Year	Council	Parliament	Commission
2000	21	25	52
2001	10	55	68
2002	29	43	99
2003	42	49	88
2004	19	17	87
2005	23	16	113
2006	51	41	106
Total	195	246	613

Note: EU = European Union. Noise was only removed for 2006.

is discussed by the College of Commissioners) and is published in the *Official Journal of the European Union*. Then, the proposal is forwarded to the European Parliament and to the Council simultaneously.

The Economic and Social Committee, representing civil society, and the Committee of the Regions, representing local authorities, must be consulted by the Commission and can be consulted by the Council and the Parliament. Thenceforth, the Economic and Social Committee and the Committee of the Regions may issue opinions in cases considered by them to be appropriate. After that, the codecision procedure takes place only between the Parliament, Council, and Commission.

Data and Method

As we aim to classify EU innovation policies, we assumed that those policies are embedded in documents. For that reason, we resorted to documents published in *Eur-lex*. This reference center provides online access to the EU official journal, treaties, legislation in force, preparatory acts, case law, and parliamentary questions.

The yearly frequency distribution of EU documents on innovation from 2000 to 2006 is shown in Table 1 and Figure 2. Firstly, the analysis was restricted to documents containing the term *innovation* either in the title or in the text. Secondly, the working database was constructed by retrieving documents published in English by the Council, the Parliament, and the Commission in the EU official journal. Thirdly, we chose only the year 2006 for illustrating typology of EU innovation policies. Finally, for 2006, we discarded those documents that contained the term *innovation* because they were not fully in line with our selected definition of innovation. In other words, we removed noise only between January 1, 2006, and December 31, 2006.

The semantic confusion of the terms *taxonomy* and *typology* is clarified by Doty and Glick (1994). The term *taxonomy* refers to a classification system that leads to categorizing innovation policies into mutually exclusive and exhaustive sets with a series of discrete decision rules, while a typological heuristic makes possible identifying multiple ideal types, each representing independent variables of the outcome. In our study, the outcome could be represented by the Lisbon goals, that is, to make the EU the most competitive and dynamic knowledge-based economy, capable of sustainable economic growth with more and better jobs and greater social cohesion.

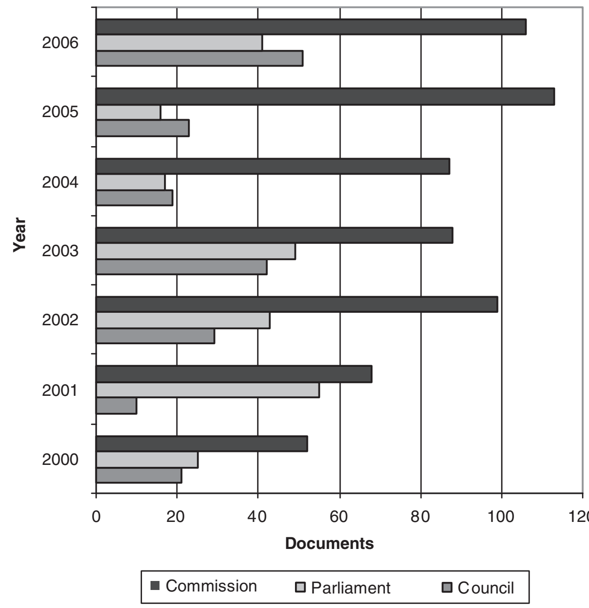

Figure 2. Chart of EU Documents on Innovation
Note: EU = European Union.

A catalogue of all aspects and instances of EU policy innovation would obviously be quite unmanageable. It would merely demonstrate that innovation policies are too diverse, too protean, to be captured in full by a single categorization. For that reason, two strategies were designed to fully tackle the classification problem of EU innovation policies.

The first strategy was to adopt two biological approaches to the problem of classification of EU innovation policies into a typology in order to provide an epistemic horizon for cognitive purposes. Firstly, a Linnaean heuristic allowed us to classify EU innovation policies into a hierarchy that starts with domains and finishes with species. Secondly, a cladistic approach permitted us to arrange innovation policies only into their order of branching in an evolutionary tree (Luria, Gould, & Singer, 1981).

In both cases, the underlying logic for each criterion is Aristotelian: Superior taxa possess similarities that are common to all lower taxa, and lower taxa possess more

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Table 2. Public Policy Instruments for Research and Development

Instruments in a Narrow Sense	Instruments in a Broader Sense
1. Institutional funding National research centers Research councils Applied research and technology development organizations Universities and other higher education institutions Others	4. Public demand and procurement
2. Financial incentives Indirect promotion programs Technology promotion programs Risk capital	5. Corporatist measures Long-term visions; technology foresight Technology assessment Awareness initiatives
3. Other innovation infrastructure and technology transfer mechanisms Information and consultancy for small- and medium-sized enterprises	6. (Continuing) education; training
Demonstration centers Technology centers Cooperation, networks, people	7. Public policy Competition policy Public stimulation of private demand

Source: Meyer-Krahmer and Kuntze (1992).

specificity that could make a difference from other taxa at the same level of classification. For example, domestic policy is the counterpart of external policy and it consists of all government policy decisions, programs, and actions that primarily deal with internal matters, as opposed to relations with other countries that are not EU member states. Major areas of domestic policy include economic policy and regulatory policy. Economic policy refers to the actions that cover interest rates, governmental deficit, and labor markets, among others. Regulatory policy refers to the implementation of rules to influence the behavior of actors in society.

The second strategy was to use a neofunctionalist heuristic for our typological approach. The ideal types are complex constructs that must be described in terms of multiple dimensions and are not categories. Instead, each ideal type represents a unique combination of the dimensions used to describe EU innovation policies.

Public policy instrumentation and its choice of tools and modes of operation are generally treated either as a kind of evidence (e.g., governing means making regulations, taxing, entering into contracts, communicating, etc.) or as if the questions it raises (the properties of instruments, justifications for choosing them, their applicability, etc.) are part of a rationality of methods. A good deal of the public administration literature devoted to the issue of instrumentation is marked by a functionalist orientation (Lascoumes & Le Gales, 2007).

In particular, Meyer-Krahmer and Kuntze (1992) have defined research and development (R&D) instruments both in a narrow sense and in a broader sense (see Table 2). The instruments used for science policy may be budgetary decisions on allocating funds to public research organizations, such as universities, and subsidies or tax relief to private firms. The instruments used in technology policy may be public procurement and direct incentives in the form of subsidies and tax reductions, supporting research at universities, finding institutional mechanisms that link universities and public laboratories to the users of research, and designing and enforcing intellectual property rights. The instruments used in innovation policy pay special attention to the institutional dimension including competence building and organizational performance, such as improving individual skills and learning abilities.

Another way of constructing a technology policy typology could be in the manner of Alic and colleagues (2003), who schematized the policy tools according to (a) direct government funding of R&D; (b) direct or indirect support for commercialization and production; (c) indirect support for development; and (d) support for learning and diffusion (see Table 3).

Taxonomy and Typology of EU Innovation Policies

The old linear model of innovation embedded the first generation of innovation policy. The second generation of innovation policy was launched in the EU in 1995. Since the 2000s, the EU innovation policies belong to the third generation, which implies having innovation at the center of all policies in the knowledge-based economy according to the Lisbon strategy. For that reason, innovation goals can be found in a wide range of policies and

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Table 3. Technology Policy Tools

Direct Government Funding of R&D	Direct or Indirect Support for Commercialization and Production; Indirect Support for Development	Support for Learning and Diffusion of Knowledge and Technology
R&D contracts with private firms (fully funded or cost-shared)	Patent prosecution	Education and training (technicians, engineers, and scientists; business decision makers; consumers)
R&D contracts and grants with universities	R&D tax credits	Codification and diffusion of technical knowledge (screening, interpretation, and validation of R&D results; support for databases)
Intramural R&D conducted in government laboratories	Tax credits or production subsidies for firms bringing new technologies to market	Technical standard setting to ensure commonality or compatibility
R&D contracts with industry-led consortia or collaborations among two or more actors above	Tax credits or rebates for purchasers of new technologies	Technology and industrial extension services
	Government procurement	Publicity, persuasion, and consumer information (including awards, media campaigns, etc.)
	Demonstration projects	

Source: Alic, Mowery, and Rubin (2003).
Note: R&D = research and development.

Table 4. Linnaean Taxonomy

Domain	Kingdom	Division	Class	Order	Family	Genus	Species
domestic policy	economic policy	industrial policy	entrepreneurial policy	innovation policy	technology policy	biotechnology policy, information technology policy, etc.	genomics policy, database policy, etc.
domestic policy	economic policy	industrial policy	entrepreneurial policy	innovation policy	nontechnology policy	organizational policy	training and education policy
domestic policy	regulatory policy	fiscal policy	tax policy	income tax policy	corporate policy	incentive policy	tax deduction policy

regulations. Innovation could be directly or indirectly addressed by the policies and regulations. In this section, the results of our typology are displayed.

The Linnaean heuristic exemplified to some extent in Table 4 shows a degree of specificity of innovation policies. To begin with, domestic policy is the complement of foreign policy and it primarily deals with internal matters, as opposed to relations with other countries that are not EU member states. Examples of the second are policies to foster innovation in neighboring countries, evaluation of innovation policies of accession countries, and improvement of innovation in third countries.

Major areas of domestic policy include economic policy and regulatory policy. For instance, the promotion of innovation for the knowledge-based economy illustrates economic policies dealing with innovation. One example of industrial policy for innovation is the encouragement of innovation in the food sector. One example of entrepreneurial policy is the state aid for small- and medium-sized enterprises (SMEs). One example of innovation policy is the innovation policy tools. Examples of technology policy are those that promote innovation in media, agriculture, health, food, fisheries, and nuclear sectors. More specific sectoral polices may deal with biotechnology or information technology policy. Among these, genomics and database policies can be found. Nontechnological aspects of innovation, such as provision of training and education as sources of innovation, can show another type of species of EU innovation policy. Regarding regulatory policies, tax deductions are an example of this criterion.

The cladistic approach here simply arranges the innovation policies in an evolutionary tree. For instance, domestic policy in the cladogram (see Figure 3) shows that technological and nontechnological policies stem from innovation policy and this comes from entrepreneurial policy that derives from industrial policy in economic policy. As it was already said, the first strategy was to adopt the two biological approaches in order to provide a frame for epistemic rationale.

The second strategy used a neofunctionalist heuristic for our typology. Thus, the following first-order constructs were formulated for this attempt: (a) content, (b) axis, (c) time horizon, (d) process, (e) action, (f) goals, and (g) division of labor.

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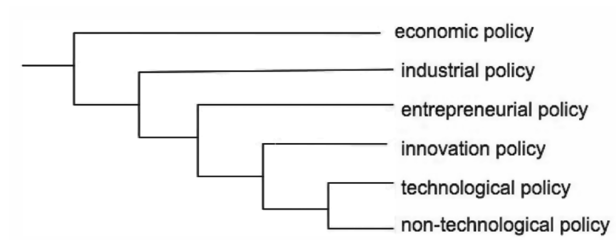

Figure 3. Cladogram

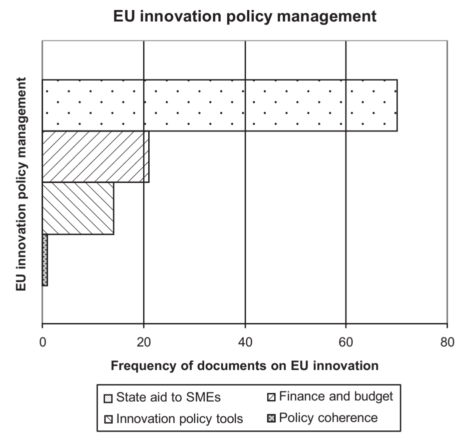

Figure 4. European Union (EU) Innovation Policy Management
Note: SMEs = small- and medium-sized enterprises.

Firstly, innovation policies content is a criterion because innovation is pervasive; many policy areas have an impact on innovation. Among the subject matter of these documents, innovation appeared in texts related to agriculture, competition, culture, democracy, development, economy, education, employment, energy, environment, EU accession, EU neighborhood, external relations, finance, fishery, food, health, human rights, information and communication technologies, manufacturing, intellectual property rights, media, networks, policy coherence, regions, science, security, social aspects, standardization, trade, transport, and youth.

Secondly, with respect to axis, innovation policies can be vertical or horizontal. Vertical policies, very important for implementation, depict relationships between different institutional layers. For instance, sectoral policies for innovation depict vertical policies, namely, improving innovation in the media and audiovisual sector, agriculture, health, food, transport, fisheries, and nuclear sectors. Horizontal policies are essential for coordination of many policy domains to achieve better innovation policy in a multisectoral approach, such as promoting innovation for a knowledge-based economy.

Thirdly, with regard to time horizon, innovation policies could be characterized as short-, medium-, or long-term. One example of the first is state aid to SMEs. One example of the second is finance and budget. One example of the third is the fulfillment of researchers' scarcity.

Fourthly, concerning policy process, innovation policies can be made collectively or institutionally (March & Olsen, 1996). Collective policy making is seen as bargaining behavior and policy as negotiated outcomes, such as developing innovation in regions. Institutional policy making implies matching institutions, behaviors, and contexts, such as maintenance of innovation in the nuclear sector.

Fifthly, as far as the action involved with innovation policies, innovation policies can cover their design, implementation, management, and assessment. Regarding the design of instruments, the Commission's proposal is the result of an extensive consultation process. Those consultative documents can be blue books, white papers, green papers, and reports. A blue book is a book of specialized information. A white paper is a detailed or authoritative report. A green paper is a document that proposes and invites discussion on approaches to a problem. A consultative report can be produced by technical experts, national experts, international organizations, or nongovernmental organizations. Regarding implementation, innovation policies can also be embodied in frameworks, actions, implementation plans, or programs. Innovation policies appear in other policy declarations. Regarding management, innovation policies can be embodied in state aid to SMEs, finance and budget, policy coherence, and other innovation policy tools (see Figure 4). Finally, the assessment of innovation policies can be embodied in reports produced by impartial experts.

Sixthly, innovation policies can have direct or indirect goals. In 2006, documents dealing with innovation policy design in a direct way contained sectoral, regional, external, labor, and macroeconomic aspects (see Figure 5). The documents that dealt with innovation policy indirectly addressed topics other than innovation such as education, environment, culture, standardization, and so on (see Figure 6).

Finally, policies can be classified by the governmental actors responsible for their design and implementation. In science policy, the main policy actors are those

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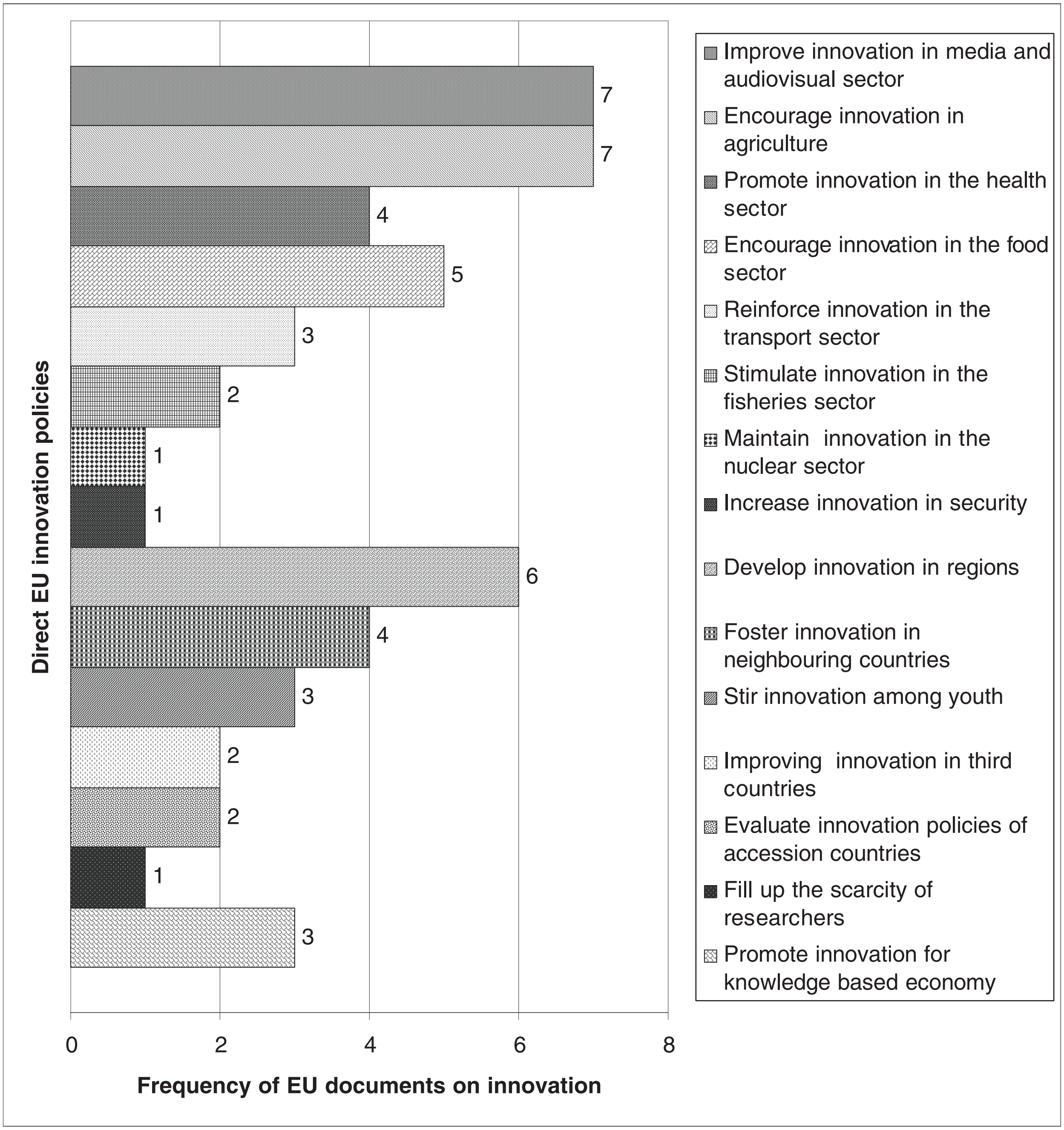

Figure 5. EU (European Union) Direct Innovation Policy Design for 2006

Commission's directorates and Parliament's committees dealing with education and research. Others, however, in charge of health, defense, energy, transport, and environment may also play a role since they organize their own research communities. Finance plays a role when it comes to deciding the budget allocation for research. In technology policy, the main policy protagonists are those directorates of the Commission and committees of the Parliament that deal with applied science and procurement of technologies. In innovation policy, the main protagonists are those directorates of the Commission and committees of the Parliament that deal with enterprise.

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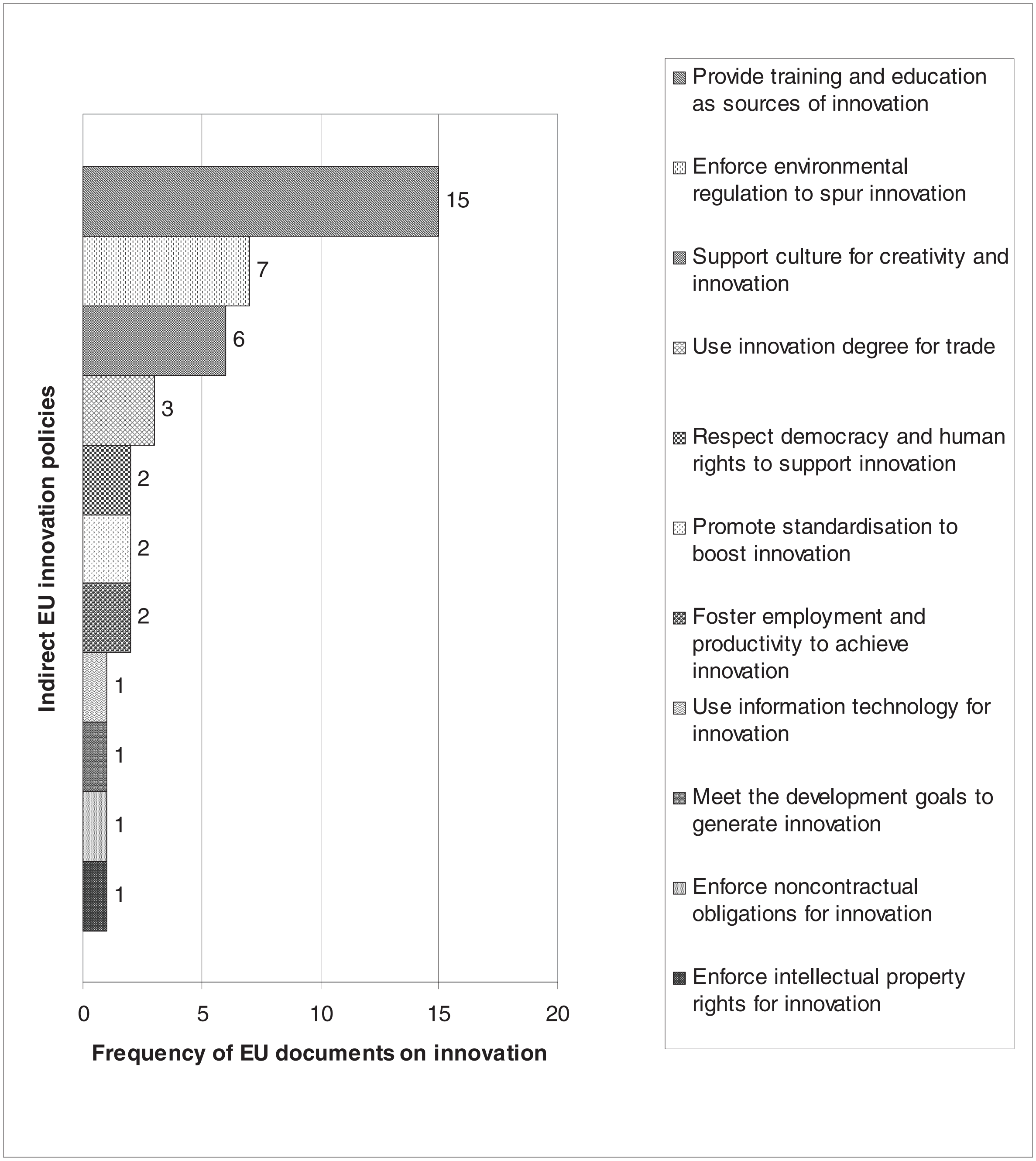

Figure 6. EU (European Union) Indirect Innovation Policy Design for 2006

Models for Innovation Policies

Innovation policy models are referred to in this section to illustrate how the historical context played a role in their construction. Bozeman (2000) modeled three paradigms differentiated by policy legitimization, viz. market failure, mission, and cooperation (see Table 5). The market failure paradigm limits innovation policy to market failures such as extensive externalities, high transaction costs, and asymmetric information. The mission paradigm limits innovation policy to the mission of government agencies but does not confine it to defense. The cooperation paradigm fosters technology transfer.

European innovation policies have been increasingly differentiated in terms of scope and instruments since the

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Table 5. Bozeman Models

Model	Market Failure	Mission	Cooperative Technology
Core assumptions	(1) Markets are the most efficient allocation of information and technology. (2) Government laboratory role limited to market failures such as extensive externalities, high transaction costs, and information distortions. Small mission domain, chiefly in defense. Universities provided basic research, in line with private sector undersupply due to market failure (inability to appropriate directly the results of basic research). (3) Innovation flows from and to private sector; minimal university or government role.	(1) The government role should be closely tied to authorized programmatic missions of agencies. (2) Government R&D is limited to missions of agencies, but not confined to defense. University R&D supports traditional roles of land grant universities such as agricultural or engineering extension, manufacturing assistance, and contract research for defense or energy research. (3) Government should not compete with private sector in innovation and technology. But a government or university R&D role is a complement.	(1) Markets are not always the most efficient route to innovation and economic growth. (2) Global economy requires more centralized planning and broader support for civilian technology development. (3) Government laboratories and universities can play a role in developing technology, especially precompetitive technology, for use in the private sector.
Peak influence	Highly influential during all periods.	1945-1965; 1992-present	1992-1994
Policy examples	Deregulation; contraction of government role; R&D tax credits; capital gains; tax roll back. Little or no need for federal laboratories except in defense support.	Creation of energy policy R&D, agricultural labs, and other such broad mission frameworks.	Expansion of federal laboratory roles and university role in technology transfer and cooperative research and other technology-based economic development programs.
Theoretical roots	Neoclassical economics.	Traditional liberal governance with broad definition of government role.	Industrial policy theory, regional economic development theory.

Source: Bozeman (2000).
Note: R&D = research and development.

1950s. Rothwell and Dodgson (1992) modeled them according to a historic approach differentiated by the degree of coordination between science and industrial policy makers (see Table 6). They displayed three phases, viz. 1950s and 1960s, mid-1970s to early 1980s, and early 1980s to early 1990s. The three phases were characterized by the degree of coordination of science and industrial policy makers, namely, little, increasing, and complete coordination, respectively.

Smits and Kuhlmann (2002) also modeled European innovation policies from a historic standpoint but they differentiated them by the primary goal of such policies. The 1970s were characterized by a financial goal for stimulating research and development, the 1980s by diffusion or technology transfer, the 1990s by managerial gaps in running businesses, and the 2000s by systems for facilitating change.

In particular, innovation policy instruments in use in all EU and preaccession countries were classified by Smits and Kuhlmann (2002) into four categories: financial, diffusion, managerial, and systemic (see Table 7). The specific instruments are shown in Table 8.

Science, Technology, and Innovation Policies

This section describes the meanings of constructs used in innovation policy studies. Firstly, science can be conceptualized as a mode of knowledge. In the domain or neighborhood, knowledge is just one member of a whole cluster of closely related entities, such as fancy, suspicion, surmise, awareness, information, opinion, belief, conviction, and so on, according to Ziman (2005). He arranged them in increasing order of credibility to indicate that knowledge is just the limit point of that set. A feature of knowledge is the notion of consensus, which Kusch (2004) envisages as precisely the elusive endpoint where knowledge is indeed achieved.

What distinguishes science from other modes of systemic inquiry is its distinctive method: the scientific method. In particular, technology is science in

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Table 6. Rothwell and Dodgson's Models

<table>
<tr><td>1950s and 1960s</td><td>Science policy
• Scientific education
• University research
• Basic research in government laboratories</td><td>Industrial policy
• Grants for R&D
• Equipment grants
• Industrial restructuring
• Support for collective industrial research
• Technical education and training</td><td>Firm size emphasis
• Emphasis on large firms and industrial agglomeration
• Creating national "flagship" companies
• Public R&D funds go mainly to large companies
• Paucity of venture capital</td></tr>
<tr><td></td><td colspan="3">Little coordination or active collaboration between science policy makers and industrial policy makers</td></tr>
<tr><td>Mid 1970s to early 1980s</td><td colspan="3">Innovation policy
• Some concern over lack of university-industry linkages
• Grants for innovation
• Involving collective research institutes in product development
• Innovation-stimulating public procurement
• Increasing interest in SMEs
• Many measures introduced to support innovation in SMEs
• Continuing paucity of venture capital</td></tr>
<tr><td></td><td colspan="3">Increasing interdepartmental coordination</td></tr>
<tr><td>Early 1980s to present</td><td colspan="3">Technology policy
• Increased emphasis on stimulating university-industry linkages
• Increased emphasis on "strategic" research in universities
• Selection and support of generic technologies
• Growth in European policies of collaboration in precompetitive research
• Emphasis on intercompany collaboration
• Emphasis on the creation of new technology-based firms
• Growing availability of venture capital</td></tr>
<tr><td></td><td colspan="3">Interdepartmental initiatives</td></tr>
<tr><td></td><td colspan="3">Growing interest in accountability and in measures for evaluating the effectiveness of public R&D policies
Increasing concern over growing regional economic disparities
National and local government initiatives to enhance R&D
Potential of the less-developed regions: accelerated establishment of regional technology infrastructures (e.g., science parks, technopoles, innovation centers)</td></tr>
</table>

Source: Rothwell and Dodgson (1992).
Note: R&D = research and development; SMEs = small- and medium-sized enterprises.

application; science in action is research (Ziman, 2000). The instrumental attitude to science is summed up by the hybrid scientific research and technological development using the acronym R&D. This linear model locates science at the upstream and innovation at the downstream.

The supposed role of research is to produce, by any feasible means, whatever knowledge is required, or seems likely to be required, in order to satisfy an actual, or envisaged, material need. Industrial R&D and other forms of applied science do indeed share the same norms also sometimes found inside large governmental laboratories. Industrial R&D and academic science are culturally very different.

Science and technology studies and policy analysis have been divided because of their disciplinary origins, major sources of research questions, emphasis on cognitive or operational problems, and focus on science and technology (Spiegel-Rösing, 1977). Science and technology studies started as a movement with a critical view of scientific and technological development and its impact on society. Later, this movement turned into an academic field more interested in knowledge creation, having taken approaches from sociology, philosophy, and history.

The science and technology policy was established as an area of government intervention in the immediate aftermath of World War II. Initially, the main area of involvement was just science. In the 1950s and 1960s, the focus was on institution building and expansion of policy for science. In the 1970s, the application and utilization of science as a policy were emphasized, with

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Table 7. Development of European Innovation Policy

	Primary Goal	Client	Content	Process	System
Financial (1970s)	stimulating R&D	one-to-one private firm	R&D subsidy		
Diffusion (1980s)	transfer of knowledge and technological competence	one-to-one private firm (public institution)	science subjects formal	limited to specific technical project	
Managerial gap (1990s)	support running a business	one-to-one one-to-few private firm	social science formal tacit	limited to specific consultancy project demand articulation strategy development	organizing small chains and clusters management interfaces
Systemic (late 1990s)	facilitating change	chains networks systems	science, social science formal tacit strategic intelligence	management complex project strategy and vision development demand articulation stimulate learning stimulate experimenting	system organizer system builder management interfaces identifying, mobilizing, involving users guarding democratic content developing infrastructure strategic intelligence

Source: Smits and Kuhlmann (2002).
Note: R&D = research and development.

Table 8. Innovation Policy Instruments From EU Member States and Accession Countries

Type of Instrument	Specific Instrument
Financial	financing taxation strengthening company research start-up technology-based companies
Diffusion	mobility absorption technologies by SMEs
Managerial	mobility innovation and management start-up technology-based companies absorption technologies by SMEs strategy, vision of R&D
Systemic	*Dynamic:* raising public awareness promotion of clustering and cooperation for innovation cooperation research, universities, companies *Static (infrastructure):* public authorities competition protection of intellectual property rights administrative simplification legal and regulatory environment education and training

Source: Smits and Kuhlmann (2002).
Note: EU = European Union; R&D = research and development; SMEs = small- and medium-sized enterprises.

technology thereby emerging more clearly as an area of concern. In the 1980s, there was a shift to innovation policy by removing the distinction between science and technology. In the 1990s, basic research became intimately intertwined with the production of goods and technological development.

Science and technology policy analysis is concerned with the governance, direction, and promotion of science and technology in the real world of science and technology (Salazar-Acosta, 2005). Science and technology policy analysis moved between different models and theories from political science, economics, and management. The terms *science*, *basic research*, and *academia* have been used interchangeably. In addition, the terms *technology*, *applied research*, and *industry* have also been employed in a similar manner.

This semantic confusion has helped to conceal important differences between them. To reduce the current state of confusion, we provide the following clarifications. Traditional literature has been used to distinguish between basic and applied research, with basic research being focused on questions of fundamental scientific interest and applied research focused on questions of usefulness and applications.

Stokes (1997) modeled research according to the consideration of usefulness and the quest for fundamental understanding. If there is an application but no quest for fundamental understanding, then the research falls into

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Edison's quadrant. If there is no consideration of usefulness, but there exists a quest for fundamental understanding, then the research falls into Bohr's quadrant. If there is both consideration of usefulness and fundamental understanding, then the research falls into Pasteur's quadrant.

Research can be conducted in industrial, governmental, or academic organizations. Basic research is not the monopoly of universities; some companies carry out basic research as well. Furthermore, applied research is not only found in industry; academia also pursues applied research. Nonetheless, the labels of basic and applied research are changing. A priori definitions of polar ideal types are vague, imprecise, and awkward for empirical operationalization in postmodern science (Callon, 1997; Kidd, 1965; Latour, 1993).

Science and technology are distinct branches of knowledge and distinct communities, with different research problems and methods, responding to different incentives. Technology involves much more than science, and innovation involves much more than technology. Innovations do not always involve the application of technology (Metcalfe, 2000). It is inadequate to think of innovation in technological terms alone (Dodgson & Bessant, 1996).

Concluding Comments

From a policy point of view, it is easier to talk about science and technology as a single concept, because technology is applied science. When the focus of policy is on innovation in Schumpeterian terms, it became clear that this catch-all concept included more than science and technology. Innovation policy is therefore more generic than science, technology, and research policies. In this sense, innovation polices may include nontechnological aspects such as organizational learning and commercialization.

The issue of the choice of instruments is intimately linked to the issue of policy design, which means the development of a systematic understanding of the selection of instruments and an evaluative dimension (Linder & Peters, 1984). Scholars of the history of technology and the sociology of science have denaturalized technical objects by showing that their progress relies more on the social networks that form around them than on their own characteristics. Simondon (1958) studied innovation not as the materialization of an initial idea but as an often chaotic dynamic that sets information, adaptation to constraints, and arbitration on a path of convergence between divergent routes of development. He went on to talk about the process of concretization, taking into account the combination of heterogeneous factors whose interactions produce—or fail to produce—innovation. Sociology of science developed this perspective by rejecting the retrospective view that suppresses moments of uncertainty and sees creation only as a series of inevitable stages moving from the abstract to the concrete, from the idea to its concretization (Akrich, Callon, & Latour, 1988). Translation of and through technical instruments is a constant process of relating information and protagonists and of regularly reinterpreting the systems thereby created.

Public policy instrumentation, in general, and innovation policy instrumentation, in particular, are therefore means of orienting relations between political society (via the administrative executive) and civil society (via its administered subjects), through intermediaries in the form of devices that mix technical components (measuring, calculating, the rule of law, procedure) and social components (representation, symbol). This instrumentation is expressed in a more-or-less standardized form—a required passage for public policy—and combines obligations, financial relations (tax deductions, economic aid), and methods of learning about populations (statistical observations).

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