ECONOMIC RATIONALES UNDERLYING INNOVATION POLICIES: ANALYSIS OF POLICY–MAKING PRACTICES IN FINLAND, SPAIN AND THE UNITED KINGDOM

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1. INTRODUCTION

The 'national systems of innovation' (NSI) approach is a theoretical framework developed during the early 90's in the economics literature, specifically within the neo-schumpeterian and evolutionary currents of thought. It was intended as a framework for economic analysis, mainly oriented to better understand the environment within which science and technology policies were designed and implemented, emphasizing the context of application of these measures and the systemic nature of innovation processes. During the last ten years, different countries seem to have explicitly or implicitly adopted elements of the NSI framework in their policy–making processes to design and implement instruments to improve their innovative and economic performance.

However, it is not clear whether this adoption has implied structural changes in the way in which innovation policies are designed and in the characteristics of policies themselves, or it is simply used as a metaphor for describing national economies with an emphasis on its capabilities to innovate. Thus, the main objective of our research is to assess to what extent the NSI approach has been actually applied for policy–making, and what are the underlying economic rationales of policy action.

2. THE POLICY–MAKING PROCESS

Models and theories are intellectual constructs that attempt to represent reality in order to understand it with certain degrees of accuracy and detail. These are built by means of reducing the real complexity of particular phenomena to a simpler and understandable one, by means of making simplifying assumptions, but the more assumptions we make, the more simplified the model will be, i.e., increasing the number of assumptions is a way of reducing complexity, and in some circumstances, this procedure is very useful though it also reduces the accuracy of the model and the amount and quality of our knowledge; thus, the resulting knowledge will be as good as its underlying assumptions[1], and this should be evaluated carefully, since planning under simplified premises always has the risk of undesirable effects. During the process of planning and policy–making, for example, a model of the system in question is made in order to get some orientation into the system complexity. Subsequently, this simplified version is introduced into the system in a self–referential process that increases the capability of the system to be constrained[2] and for constructing order by reducing complexity[3].

1 See Allen (2001).
2 Interrelationships within a system work as constraints on the behaviour of the elements or subsystems involved as means to limit variety.
3 See Luhmann (1995).

Allen[4] suggests a set of assumptions that are helpful to describe and analyse industrial (innovation) processes as well as the economic models which are currently used to justify science, technology and innovation policies: first, a system and its environment are defined; secondly, rules for the classification of the components in the system are determined; thirdly, it is assumed that the components are either identical or have normally distributed properties about an average; fourthly, it is supposed that the system behaviour can be adequately described by the average of individual events or element properties; fifthly, the assumption that the system will naturally move to an equilibrium state is made.

Neoclassical economics for example, makes use of the five assumptions to describe economic systems in terms of a static model with rigid rules for the properties and behaviour of the elements of the system. On the other extreme, evolutionary approaches of innovation make use of only the first two assumptions to describe economic systems as evolutionary complex systems. While the former has the advantages of its simplicity and the apparent possibility of looking at policies in terms of stationary states, before and after the decisions are made, it has the disadvantage of sweeping many details of the processes occurring in the system aside. On the other hand, the latter approaches have made significant advances in the understanding of the detailed process of innovation and the complex set of interactions that make it possible, but due to the complexity involved, the models are still incomplete or lack of sufficient formalisation, and the policy recommendations derived from them are fairly general and diffuse. There are in this case many more policy targets, but precisely due to the nature of the models involved, we have neither means to choose or to distribute resources among them, nor an efficient way to measure how these efforts have an impact on a particular innovative performance.

From a policy–making perspective, the main question is then “whether or not a simple enough description can be found that is still sufficiently realistic to be useful”[5], which in this case implies to assess the quality and usefulness of the knowledge we are obtaining with these models, the simplicity, effectiveness and efficiency concerning the implementation of the policies derived from them, and even the possible complementarities and conflicts that could appear if we decide to use a mixed approach[6].

3. THE CLASSIFICATION OF INNOVATION POLICY MEASURES

The classification of policy measures is usually addressed from two main perspectives: the nature, characteristics or delivery mechanisms and the objectives or goals of the policies. The first approach distinguishes for example, if the measures are financial or not, direct or indirect, horizontal or oriented to a specific sector, and so on, while the latter attempts to identify the deficiencies that the measures are trying to correct. The most common practice is to use a mixed approach building matrices that combine the range of types and objectives to characterise what different authors call the ‘policy mixes’[7] of particular countries, though they do not necessarily refer to the same thing. In what follows we will briefly analyse some of these typologies

4 Op. cit.
5 Allen (2001, p344)
6 Cf. Lipsey (1998).
7 See for example Boekholt et al (2001).

organised in two groups, those primarily based on delivery mechanisms and those on deficiencies addressed

CLASSIFICATIONS PRIMARILY BASED ON DELIVERY MECHANISMS

The policy mix expert group set up by the European Commission to synthesise the work of several task forces devoted to explore the potential of different financial and fiscal policy instruments[8], suggested a classification based on a three dimensional space to differentiate R&D and innovation policies and their area of application. The first dimension proposed distinguishes between types of delivery mechanisms: direct financial, indirect fiscal, catalytic and other direct measures. The first type involve the direct transfer of financial support for R&D; the second implies the public sector forsaking tax income from the private sector in exchange for approved R&D investment behaviour; the third includes actions taken by the public sector that help R&D performers to access external sources of finance, e.g. risk capital and loan and equity guarantee measures; and, the last type covers support for R&D and innovation performers other than the provision of finance for projects, e.g. access to advice, brokerage schemes, funding for networks, etc. The second dimension distinguishes between objectives of the measures in terms of policy instruments designed to support R&D, innovation activities and an intermediate category for a mix of both types of actions. Finally, the third dimension distinguishes between the actors to whom the policies are aimed and also identifies three categories: public and private sector agents and a combination of both.

Additionally, the same report suggests a set of framework conditions or policies that correspond to other policy domains but have an important influence on research, development and innovation. This group includes policies oriented to guarantee macroeconomic conditions, support for public research, the provision of human resources, the promotion of entrepreneurship, intellectual property rights, standards and regulations and competition policies. These measures are actually treated in the report as an extension of the first dimension used in the classification.

CLASSIFICATIONS PRIMARILY BASED ON DEFICIENCIES ADDRESSED

From a theoretical perspective, Metcalfe[9] suggests a broad distinction based on the concept of innovation possibility frontier[10], identifying on the one hand policies oriented to shift the innovative possibility frontier of firms and on the other, policies which induce firms to locate at a different point on their current frontier. The first group includes policies and instruments which enhance the external supply of knowledge to firms, measures to increase the connectivity between economic agents, and the national infra-technology of metrology and standards. The second group mainly includes different types of subsidies to R&D activities together with public procurement policies which increase the demand for innovation outputs.

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8 See European Commission (2003a).

9 Metcalfe (1995a); see also Metcalfe and Georghiou (1998)

10 The innovation possibility frontier is usually defined either as the relation between the improvement in product performance and a given innovative expenditure achieved in a given time period, or the relation between the time taken to achieve a given improvement and the cumulative effort devoted to making that improvement.

Working within a similar framework, Lipsey[11] distinguishes between two broad categories to classify policies, the objectives and the scope of the measures. Concerning the objectives, he adopts the innovation possibility frontier concept already mentioned, to differentiate between policies intended to alter the costs or returns to investment in inventive and innovative activities; and policies aimed at altering the facilitating structure within which technology is embedded at any moment of time and altered over time. Regarding the scope or breadth of the policies, he suggests the distinction between framework, focused and blanket policies. The first group comprises policies which provide general support for a specific activity across all the economy, such as intellectual property rights, tax exemptions and general subsidies. Focused policies, on the other hand are designed to encourage the development of specific technologies, particular industries and types of R&D activities and of firms. Finally, blanket policies combine elements from both, and are designed to accommodate a number of technological objectives at once, e.g. increasing technological competences of firms. These typically incorporate multiple instruments and require assessment mechanisms to tailor the assistance they provide. According to Lipsey, Framework and focused policies usually are intended to alter the returns to investment, while blanket policies tend to modify the facilitating structure.

From a more pragmatic perspective, the European Commission's Action Plan on Innovation in Europe[12] proposes a general categorisation of innovation policies based on its three main objectives: fostering an innovation culture, establishing a framework conducive to innovation and gearing research to innovation. These priorities are subsequently divided into 17 sub–themes which constitute the analytical classification used to monitor developments and trends in the EC Trend Chart on Innovation[13] operated by DG Enterprise of the European Commission. Although it seems to be a straightforward approach, an in–depth analysis shows that for classification purposes these objectives and their subdivisions are fairly ambiguous or they fail to include all the range of possible instruments, e.g. funding of public research.

A more comprehensive typology is proposed by the expert group commissioned by the EC DG Research[14] to analyse direct support measures, which departs from the identification of four broad categories[15] of problematic areas addressed by policies: resources for innovation, incentives for networking activities, capabilities of firms and the generation of opportunities for innovation. Subsequently, several general delivery mechanisms are cross–analysed against the categories of objectives addressed. In a second step, another broad distinction between supply and demand instruments is made, the former including policies which are intended to provide resources and capabilities for innovation, through financial measures and services; and the latter consisting of policies which ultimately seek to increase the incentives and opportunities associated with innovative activities. Finally, a hierarchical tree is built, organising specific delivery mechanisms in the broad branches of supply and demand policies (see Figure 1).

11 Lipsey (1998).
12 See Cordis (1996).
13 See for example Trend Chart (2003).
14 Se European Commission (2003b)
15 See also Metcalfe and Georghiou (1998)

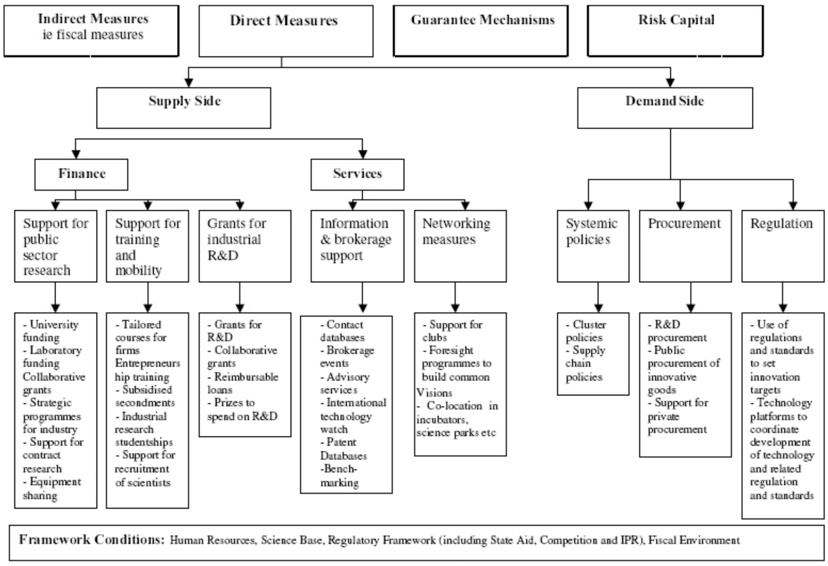


Figure 1 EC–DG Research direct measures typology

The European Commission, through DG Competition has recently elaborated a working document about Community rules on state aid for innovation[16] that suggests a typology based on the specific 'market failures' addressed by policy instruments. These failures include: the positive externalities and public good nature and appropriation problems of knowledge, information asymmetries and inefficient dissemination of information, uncertainty and imperfections of capital markets, and labour market rigidities and mismatches. Subsequently, the document suggests groups of delivery mechanisms designed to address these deficiencies, though not all of them correspond to instruments that could be unequivocally considered as state aid. It is also worth noting that in this document, market failures and the instruments to correct them are approached in a flexible non–orthodox way, suggesting that notions such as the non–linearity and the systemic properties of the innovation process have started to permeate into traditional economic interpretations (see Table 1).

Finally, an interesting typology related to the development of performance indicators within a systemic framework was suggested by the expert group working for the European Commission DG Research in the elaboration of the report on the impact of research and technology development on competitiveness and employment[17]. This is essentially built by a broad distinction between reinforcing and bridging policies, aimed at four different types of agents defined by their activities and affiliation within the system as knowledge producers and users from the public and private sectors. Reinforcement policies are thus intended to strengthen or support mainstream activities performed by each of the four types of agents, while bridging policies are designed to link agents together via actions that encourage or enable them to benefit from increased exposure to each other. The typology thus suggests four types of reinforcement and bridging policies and an additional type of 'systemic policies' in the centre of a two dimensional space[18].

16 EC DG Competition (2004)

17 See Soete et al (2002)

18 However, it could be argued that bridging policies are also systemic.

Table 1 EC-DG Competition classification of measures by market failures addressed

Deficiencies addressed	Policy instruments
Appropriation problems and externalities	• Support to performing R&D firms • Assistance to enterprises in the patenting process • Funding of shared knowledge (partnerships industry/university) • Competitive funding of research and innovation (grant programmes) • Spin-off of enterprises • Aid to innovative and environmentally sound products, services and processes • Aid to innovation investments • Aid to incubation facilities
Information asymmetries	• Promotion of clustering and networking activities • Measures to promote knowledge diffusion (knowledge services, libraries, education, training, fairs) • Facilitation of technology transfer and interfaces (e.g. industry-science relations, research joint ventures for development of innovative products/processes, science and technology parks) • Support to intermediary actors (e.g. technology consultants, IPR brokers)
Uncertainty and imperfection of capital markets	• Promotion of the risk capital market and financing of innovation via seed capital, venture capital, business angels in start-up and development phases • Public funding to pre–competitive research (while letting competition forces operate when moving closer to the market), Research joint ventures • Public funding of large, risky projects
Labour market mismatches	• Support to investment in human capital, training, life long learning, improvement and continuous training of existing personnel, including researchers • Support for recruitment of scientists, engineers and doctoral candidates

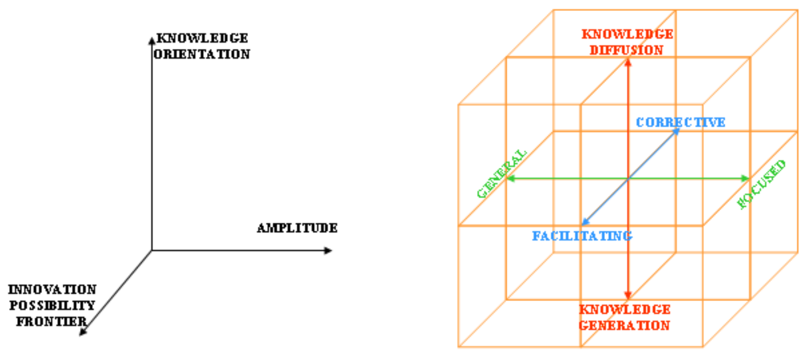
4. Suggested classification and method of analysis

In this part of our study we are primarily interested on the rationales for public intervention on innovative activities. As we have previously discussed, the process of policy–making implies the construction of a simplified model of reality based on sets of assumptions which help to reduce the complexity of the system under analysis. Traditionally, policy–makers involved with research and innovation have relied, at least discursively, on models based on a neoclassical perspective of the economic system. Thus our purpose is to assess if the current innovation policies are based on the set of assumptions that this model requires or to what extent they have departed from it and started to rely on a different explanation. This means that concerning the classification of policy measures, we need to use a mixed approach primarily based on the assumptions needed to model the system and consequently to design the specific instruments, while simultaneously taking into account the deficiencies that the policies attempt to address. In a second stage, different delivery mechanisms can be associated with particular policy types.

If we recall the set of assumptions that was previously mentioned, the third, fourth and fifth ones are relevant for our purpose here, i.e. those concerning the homogeneity and the behaviour of the economic agents for whom the policies are intended, and that concerning the equilibrium of the system. These factors imply in turn the scope and the objectives of the policies in a similar way as the Metcalfe's and Lipsey's approaches that we mentioned above. Thus the acceptance or rejection of the supposition about the homogeneity of the actors faces us with a dichotomy between general or framework policies and focused policies. Similarly, the acceptance or rejection of the assumption related to an average behaviour of the agents, confronts us with a distinction between corrective and facilitating policies. Finally, we can differentiate between the types of knowledge that the measures attempt to promote as an additional dimension connecting the amplitude and the objectives of the policies, and thus we distinguish between instruments aimed at the generation and the diffusion of knowledge.

We suggest then a three–dimensional policy space with the following axes: amplitude: from general to focused; objectives: from corrective to facilitating; and, types of knowledge: from generation to diffusion. In this space we can have eight combinations of instruments or measures with the policies which *can be devised* using a simplified model of the system on one extreme; and on the opposite the policies which, the rejection of the assumptions, allows to design (see Figure 2). We can say that the former correspond to an orthodox market failure approach and the latter to a systemic approach. In the middle we have what can be called transitional policies, which depending on the assumptions that are accepted or rejected will be closer to the market failure or the systemic approaches. It is important to note that the insistence on the idea of the model of the system and its premises is to remark the fact that *given certain number of suppositions, the resulting model will only be capable of providing information for policy design within the limits imposed by those assumptions*. For example, the orthodox market failure approach can only suggest horizontal, corrective policies because the model does not yield information about economic or

Figure 2 Innovation policy space



technological structures nor about specificities of the agents apart from an optimising behaviour.

For the sake of simplicity, we reduced the number of categories to the six policy types that are shown in Table 2. It includes a classification of the typical set of delivery mechanisms for innovation policies to identify in abstract terms the correspondence between instruments and types of policy. This analysis was performed with the help of a decision tree that was developed to assess the specific policy–mix of the countries which will be studied in the next section. It should be noted that many of the instruments in the table could be simultaneously classified within several types of policy. This only means that under specific circumstances a particular instrument could be applied with different amplitude, objectives and knowledge orientation, e.g. direct funds for public research could either be applied horizontally on the basis of quality or excellence assessments, aimed at enhancing the facilitating technology structure and to the generation of knowledge (type II); or they could be focused to attend priority research areas with the same objectives and orientation (type VI).

Table 2 Types of innovation policy measures and delivery mechanisms

	General			Focused		
	Corrective Type I Policies Orthodox Market Failure General / Corrective / Knowledge Generation and Diffusion	Facilitating Type II Policies Transitional with Emphasis on Average Agents and Knowledge Generation	Facilitating Type III Policies Transitional with Emphasis on Average Agents and Knowledge Diffusion	Corrective Type IV Policies Transitional with Emphasis on Average Behaviours and Knowledge Generation	Corrective Type V Policies Transitional with Emphasis on Average Behaviours and Knowledge Diffusion	Facilitating Type VI Policies Systemic Focused / Facilitating / Knowledge Generation and Diffusion
Direct Financial Measures						
Public Research						
University Research Funding						
Human Resources						
Infrastructure Support						
Grants for Industrial R&D						
Collaborative R&D						
Public Procurement						
Indirect Financial Measures						
Volume and Incremental fiscal measures						
Catalytic Financial Measures						
Risk Capital, Loan and Equity Guarantees						
Other Direct Measures						
Information and Brokerage						
Awareness Schemes						
Networking Measures						
Co-location Measures						
Indirect Regulatory Measures						
Intellectual Property Rights						
Competition Policy						
Standards and Regulations						
Mixed Measures						
Cluster Policies						
Foresight						

METHODOLOGICAL OBSERVATIONS

In the next section, we will briefly present and discuss an overview of the public support systems for R&D and innovation in Finland, Spain and the UK as well as an attempt to apply our typology of measures to assess their policy rationales. The reviews are abridged versions which synthesize information from policy documents, ministerial reports, external evaluations, European Commission reviews and academic studies among other sources of information. On the other hand, the analysis of the innovation policy rationales is based on the effort devoted to R&D and innovation activities, and is thus limited to budget allocation of resources to particular instruments, which means that the effort devoted to non–budgetary measures should be evaluated in the future with other methods. In other words, an important group of policies, much likely to be of the ‘type I’ in our typology, such as competition or IPR, cannot be included in the analysis, either because they are self–financed or they represent a small amount of budgetary effort which is not always included in statistical or ministerial reports[19].

The majority of the budgetary information used was compiled from ministerial annual reports and contrasted for consistency with the GBOARD figures on OECD science and technology statistics. In the case of Spain, the information was inconsistent, partly because a ministerial reorganisation affecting the support structure for science, technology and innovation has been taking place since 2004, and it has not been possible to have access to all the sources that are needed; and on the other hand, an important part of the budget is administered by the autonomous regions and devoted to regional programmes and we have not been able to consolidate this information. The case has been treated as if the figures obtained, corresponded to the whole national government spending on R&D and innovation.

5. ORGANISATION AND RATIONALE OF GOVERNMENT SUPPORT FOR R&D AND INNOVATION

GOVERNANCE OF PUBLIC SUPPORT FOR R&D AND INNOVATION

Finland

The Finnish government explicitly adopted at the beginning of the 1990s the National Systems of Innovation concept as a guide to design and implement science, technology and innovation policies. This adoption was useful to redefine and align several institutions that in some cases have been operating since the 1960s. However, during the decades of the 1960s to the late 1980s, Finnish industrial policies have relied on short–term macro–economic measures to secure growth and employment. These were compatible with an economy characterised by regulated markets and typically covered subsidies to ailing industries, infant–industry protection and frequent devaluations to boost export industries. Consequently, several interrelated circumstances, among them the deregulation of financial markets and the collapse of the Soviet Union, revealed the structural inefficiency of the Finnish economy and in

19 In the case of the UK, some figures were obtained concerning some competition policies.

the autumn of 1990, it collapsed to the most severe depression in independent Finland's history[20].

The urgent need to develop and put into practice new policy models was not only a response to the structural pressures, but also because the negotiations for European Union membership were now underway and the previous type of policies would be constrained by common EU regulations governing monetary and trade policies.

As mentioned above, the main building blocks of the new Finnish innovation policy doctrine for the 1990s were found in the concepts of national systems of innovation and of the knowledge based society. The former was rapidly adopted by the Science and Technology Policy Council (STPC)[21] in 1990, under the influence of the OECD's Technology and Economy Programme launched in 1988[22]. The Finnish interpretation of the notion gave policy planners the arguments for improving the framework conditions for business firms by increasing the public R&D funding, communication infrastructures and the education system, and supported the efforts to intensify national and international R&D cooperation.

Within the general guidelines established by the STPC, the Ministry of Trade and Industry published in 1993 the white paper "National Industry Strategy for Finland"[23], which redefined industrial policy along the lines of 'industrial clusters' as introduced by Michael Porter[24]. Despite the heterodox theoretical foundation of this model, it is a broad framework that emphasises the importance of human capital and knowledge spillovers and the creation of advanced production factors well in line with the concept of national systems of innovation[25]. In fact, the early adoption of the NSI approach as the basic framework of innovation policy facilitated the rapid diffusion of the notion of industrial clusters[26].

The conception of the science based society, once more influenced by OECD recommendations[27], was launched by the Science and Technology Policy Council in 1996[28] as the key concept of the Finnish innovation strategy to enter into the new century. This was based on the recognition of the significance of knowledge–intensive growth for the national economy and on the identification of several innovation policy measures required in addition to macro–economic and labour market measures to ensure its growth. Consequently, measures related to R&D, education, competitive conditions, intellectual property, national and international networks of cooperation and technology transfer and exploitation complemented appropriately the concept of national system of innovation.

In practice, the Finnish system of public support to R&D and innovation is quite straightforward with the Science and Technology Policy Council, a cabinet level committee, as the main responsible of the general policy guidelines and the ministries

20 See for example: Schienstock & Hamalainen (2001) and Ylä –Anttila & Palmberg (2005)
21 STPC (1990).
22 OECD (1992).
23 MTI (1993)
24 Porter (1990); see Numminen (1996) and Ylä –Anttila & Palmberg (2005)
25 See for example Molina (2000)
26 See Ylä –Anttila & Palmberg (2005)
27 OECD (1994).
28 STPC (1996)

of Education and Trade and Industry, through the Academy of Finland and the National Technology Agency (Tekes) as the main implementation institutions[29].

Spain

The Spanish public system of support of R&D and innovation has suffered various changes at least during the last 25 to 30 years. This could be the result of the different visions of the political parties in charge of the government and of extensive negotiations between the political agents at national and regional levels. In fact, an important ministerial reorganisation, suppressing the Ministry of Science and Technology, created in 2000, was approved in 2004, just a few months after the new government started its functions. This reorganisation has returned to a decentralised framework similar to the one existing in previous years and there is still some speculation concerning further changes in the near future[30].

However, the key breakthrough for the Spanish R&D and innovation policy took place in 1986 with the enactment of the *Law of Promotion and general coordination of scientific and technical research*[31]. This was aimed at: the introduction of science and technology into the political agenda; fostering coordination between the public sector by establishing an Inter–ministerial Commission of Science and Technology; allowing the interaction between the social and economic actors, the regional governments and the policies for research and innovation through the creation of the Advisory Council for Science and Technology and the General Council for Science and Technology; and, driving potential action through the establishment of a *National Plan for Research and Development* focusing on priorities and funding research through competitive mechanisms.

Thus, the Law for Science, as it is colloquially known, established the institutional layout and the main mechanism, the National Plan, for the design, coordination, and implementation of science, technology and innovation policies and measures. The National Plan is a four–year strategic plan, prioritised in thematic, strategic and horizontal programmes, to fund a wide range of research and innovation activities performed by public and private agents as well as diverse education and training actions at different levels. It is elaborated with the participation of an ample group of experts from various sectors and the Ministry of Education and Science currently coordinate its fifth edition; this later is also the main operator jointly with the Ministry of Industry, Tourism and Trade[32].

What in a first instance seems to be quite simple is in practice very intricate, since the Plan currently involves 34 programmes and 30 different types of projects or actions, operated with the participation of eight ministries. Universities, public and private research institutions and firms at the national level, in turn execute the projects and there is also the participation of several interface institutions promoting collaboration between public and private institutions. Additionally, there are an important number of R&D and innovation activities which are performed outside the area of influence of

29 There are several other mechanisms and institutions in charge of the implementation of innovation policies, also dependant of these two ministries; for a description of some of them, see for example Georghiou et al (2003).

30 See Trend Chart 2004.

31 See Sanz (1997) and Muñoz (2002).

32 CICT (2003), and MEC (2005).

the National Plan, since the autonomous regional governments have their own R&D, industrial and innovation plans and programmes. In real terms, the National Plan only allocates to its projects one third of the government R&D budget[33]

Although further in–depth study is required, it seems that the formulation and subsequent implementation of the Law for Science through the National Plans has followed some general OECD guidelines for the organisation of science, technology and innovation activities in an attempt to modernise the Spanish system making it closer to the models adopted in other OECD and European countries[34]. By the mid–1990s the notion of national systems of innovation was introduced into the political arena through the efforts of an entrepreneurial foundation, COTEC Foundation for Technology Innovation, which also has been coordinating the elaboration of detailed studies of the Spanish system of innovation[35]. Currently, the basic description of the system as well as the notions and terminology proposed in these studies is used in policy documents such as the National Plan[36].

United Kingdom

According to Gummett[37] the current governmental arrangements for science and technology in the UK have their roots in the developments which took place during the first half of the XX century. He argues that the patterns of support have persisted with little evidence of any attempts at a radical departure with the exception of some institutional innovations in the mid–1960s and in the mid–1990s. The former included a series of debates about the need for prioritisation due to the relatively high costs of certain areas of science and a subsequent reorganisation of the institutional layout with the establishment of the ministries of Education and Science and of Technology and the structure of the Research Councils.

At the beginning of the 1990s the Office of Science and Technology (OST) was created to act as the mechanism for developing and coordinating government policy on science and technology, to establish better links between government funded research and industry, and to supply well–trained and skilled human resources. In 1993, OST initial efforts culminated with the publication of the White Paper, *Realising our Potential: A Strategy for Science, Engineering and Technology*[38], which was the first major policy statement for science and technology in twenty years, and is perhaps even today the key document concerning the organisation of R&D and innovation activities in the UK. Its main points included the creation of the appropriate mechanisms for setting research priorities; the launch of a national Technology Foresight Programme as a systematic interchange between industry, scientists, engineers and policy makers to enhance the relationship between research and its commercial exploitation; the proposal of several mechanisms to improve the coordination of government funded science and technology; and, the most extensive reorganisation of the Research Councils since the 1960s.

33 Estimated from MCYT (2003).
34 See for example OECD (1987).
35 COTEC (1988); and COTEC (2004).
36 CICT (2003).
37 Gummett, P (1991).
38 Chancellor of the Duchy of, L. (1993).

As can be inferred from its objectives and activities, OST had a wide range of responsibilities concerning R&D and innovation and was originally located at Cabinet level, but in practice, it was put in charge of less than 20%[39] of the government spending on R&D, while the rest of the budget was controlled by several other government departments. Later in 1995, OST was moved into the Department of Trade and Industry (DTI); arguing that it was a better location to implement within industry the priorities identified in the Technology Foresight Programme, the move was thus intended to enable OST to work more closely with those responsible in the DTI for encouraging business to make more effective use of the science base[40].

The current organisation of the system for public support of science, technology and innovation in the UK is rather complex, with several advisory bodies at different levels and various operators at ministerial or departmental and sub–departmental level. However, concerning general and operational issues the most important tasks are performed by the Council for Science and Technology (CfST), the Department of Trade and Industry and its Office of Science and Technology, the Research Councils and the Higher Education Funding Councils. CfST is the UK government's top–level advisory body on science and technology policy issues. Its remit is to advise the Prime Minister and the First Ministers of Scotland and Wales on strategic issues that cut across the responsibilities of individual government departments, taking a medium– to longer–term proactive approach[41].

The Secretary of State for Trade and Industry has overall responsibility for the Government's science policy and support for Science and Technology and has a cross–Departmental role as the Cabinet Minister for Science and Technology. The Secretary of State is supported in this role by the DTI's Minister for Science, and the Office of Science and Technology. The majority of DTI's science, engineering and technology expenditure are devoted to funding the science and engineering base and supporting the development and use of science and technology in industry. A technical, legal and design infrastructure to support the setting of technical standards and business confidence in innovation is also maintained, including institutions such as the Patent Office, the National Measurement System and the Design Council among others. Additionally, the department aims to create the right climate for innovation by changing attitudes within the public and private sectors and operates or funds several schemes for the promotion of innovation in firms, mainly based around the identification and diffusion of best practices and the exchange of people, their ideas and expertise[42].

Finally, the Research and Higher Education Funding Councils are responsible for the so called dual 'support system'. In this scheme, Higher Education Funding Councils in England, Scotland and Wales and the Department for Employment and Learning for Northern Ireland, provide funding for research infrastructure in universities, including academic staff salaries, premises and research facilities, on the basis of a four–yearly national quality assessment, the Research Assessment Exercise. On the other hand, the Research Councils support UK–wide specific research projects and programmes in the higher education sector and in some cases in their own institutes,

39 One third if military expenditure is excluded.

40 See Flanagan, K and M Keenan (1998); and Boekholt et al (2002)

41 See CfST on the Web.

42 See Cunningham and Malik (2004).

units or centres. The types of support include grants, fellowships, studentships and the provision of large–scale research facilities. The Research Councils' funding is a mixture of 'responsive modes' and broad thematic programmes, and in addition they sponsor a series of special initiatives either in key government priority areas or in areas identified by the councils themselves[43].

RATIONALES FOR PUBLIC INTERVENTION

To provide an initial insight into the evolution of governmental expenditure oriented to R&D and innovation, Table 3shows the compound rate of growth during the 1990s, of the gross domestic expenditure on R&D for the countries under study. It is evident that there are important differences between the UK, where the government and the public sector kept a relatively stable level as financer as well as performer of R&D activities; Spain, where the government did not increase its direct intramural expenditure, but it did so through the higher education sector; and Finland where in contrast the government increased its intramural expenditure, but reduced the financing of the higher education sector.

In our more thorough analysis of innovation policy measures[44], the amount of government support for R&D corresponds respectively to 1.05%, 0.37%[45] and 0.64% as proportion of GDP for Finland, Spain and the UK. The detailed distribution and classification of these financial resources among different policy instruments is shown in Table 4and Figure 3. As can be appreciated, the policy mixes of each country are very similar, with around 40 percent of effort devoted to transitional policies of the types II and III, 40 to 45 percent oriented to transitional policies of the types IV and V, and 10 to 20 percent of systemic policies.

It is important to mention that this later group of policies correspond in all the cases to support provided to public research either through grants for projects in priority areas or through the investment in infrastructure. With the available data it was not possible to identify systemic policies oriented to private sector users, mainly because the information is not sufficiently disaggregated. For example, it is known that Finland promotes cluster policies, but it has not been possible to find budgetary information about them. Similarly, all the countries devote some kind of efforts to carry out foresight activities, which in one way or another have impacts on industrial activity, but there is no disaggregated information about the resources allocated to these.

Thus, according to our analytical framework, at least 40 percent of the financial support provided by governments to R&D and innovation, in the countries under study, still correspond to instruments based on a market failure rationale. This is mainly due to the important number of resources oriented to the general funding of universities and to research grants for basic science, both usually allocated through general competitive criteria based on excellence. On the other hand, there is an important proportion of resources, also around 40 percent, oriented to both public and private actors, to perform a wide range of activities from applied research to commercialisation, which suggest a systemic nature, or at least are designed without

43 See OST (2002) and Boekholt et al (2002).

44 Which correspond respectively to the years 2003, 2001 and 2002 for Finland, Spain and the UK.

45 As mentioned before, the data for Spain are incomplete. According to OECD MSTI statistics these figures should correspond to 1.01%, 0.69% and 0.77% respectively.

taking into account all the assumptions and restrictions imposed by the market failure rationale. Notwithstanding, we have to mention that this instruments also have a corrective orientation, which means that they are intended to alter the costs or returns to investment in innovative activities, i.e. they assume an average behaviour of the economic agents.

Table 3 Compound growth rate of GERD 1991-2000

Finland

	Sector of performance				
Funding sector	Business enterprise	Government	Higher education	PNP	Total
Business enterprise	15.97%	4.46%	10.29%	9.12%	15.57%
Government	8.52%	2.40%	13.18%	28.64%	7.52%
GUF			4.17%		4.17%
Higher education	..	..	-9.60%	..	-9.60%
PNP	53.32%	14.25%	5.55%	21.58%	17.42%
Abroad	-40.03%	13.26%	9.15%	54.42%	-11.51%
Total	10.92%	1.29%	6.12%	23.84%	8.49%

Spain

	Sector of performance				
Funding sector	Business enterprise	Government	Higher education	PNP	Total
Business enterprise	4.23%	5.79%	2.90%	21.75%	4.23%
Government	-1.60%	-0.72%	2.25%	9.42%	-0.21%
GUF			6.05%		6.05%
Higher education	93.60%	5.86%	7.51%	-4.26%	7.94%
PNP	32.69%	22.84%	11.42%	7.31%	17.09%
Abroad	-5.31%	16.89%	13.80%	27.99%	2.41%
Total	3.39%	0.58%	7.06%	9.97%	3.86%

UK

	Sector of performance				
Funding sector	Business enterprise	Government	Higher education	PNP	Total
Business enterprise	1.24%	2.08%	2.89%	21.60%	1.36%
Government	-4.44%	-1.21%	5.84%	-16.89%	-1.10%
GUF			0.62%		0.62%
Higher education	..	27.08%	2.82%	-2.55%	3.57%
PNP	-34.22%	-1.71%	8.91%	6.84%	7.19%
Abroad	4.48%	7.85%	8.12%	23.57%	4.95%
Total	1.19%	-0.50%	3.90%	-1.01%	1.44%

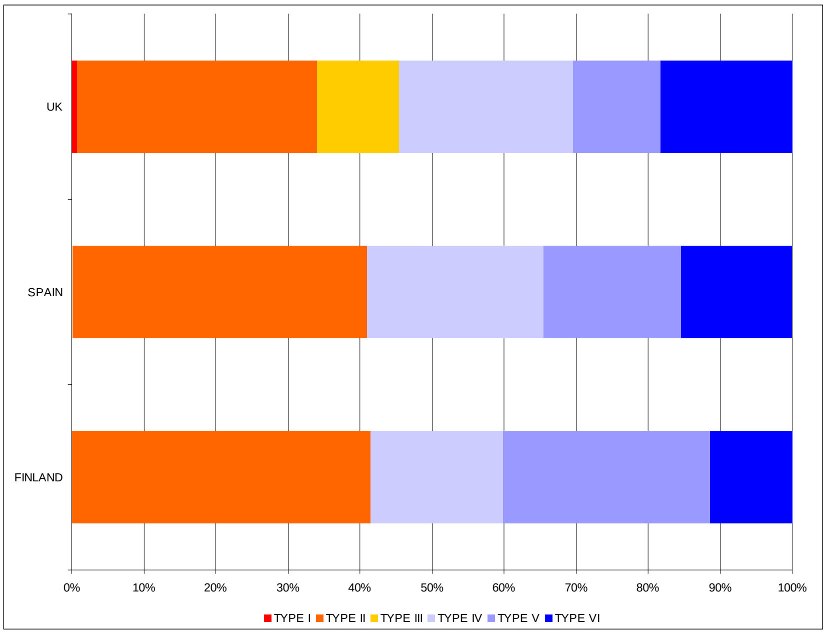
Source: own elaboration from OECD Science and Technology Statistics

Table 4 Distribution of innovation policies by types and delivery mechanisms

	FINLAND		SPAIN		UNITED KINGDOM	
	Instruments	Effort (%)	Instruments	Effort (%)	Instruments	Effort (%)
TYPE I			Volume and incremental tax exemptions	0.14	Consumer and competition policies	0.71
TYPE II	General university funding Academy of Finland funding of public institutions R&D	41.51	General university funding National Plan basic research funding for public institutions	40.87	General university funding (HEFCs) Research Councils funding of public basic research	33.35
TYPE III					Promotion of commercial best practices Labour policies Energy policies Environmental policies	11.40
TYPE IV	Tax exemptions (not for R&D but for attracting human resources) Complementary funding of public research centres (VTT) Tekes funding of industrial R&D	18.36	National Plan industrial grants for applied research on priority areas	24.47	Tax exemptions (SMEs and large firms differentiated programmes) Civil departments R&D expenditure	24.12
TYPE V	Tekes Technology Centres (regional development) Risk capital loan and equity guarantees (Tekes, Finvera, Finpro, Sitra)	28.77	National Plan industrial grants for development and networking activities National Plan risk capital loan and equity guarantees	19.07	Risk capital loan and equity guarantees Knowledge transfer programmes for industry Knowledge transfer programmes for scientific research institutions Programmes to strengthen regional economies	12.19
TYPE VI	Tekes funding of public scientific research	11.37	National Plan funding of applied research on priority areas National Plan expenditure devoted to science and technology infrastructure	15.44	Research Councils funding of engineering and technology areas Expenditure on science and technology infrastructure	18.23

Sources:
For Finland: MTI (2003); Tekes (2005); Sitra (2005); Gibbons et al (2004); Georghiou et al (2003).
For Spain: MCYT (2003) Informe del Ministerio de Ciencia y Tecnología 2001-2002, Madrid.
For the UK: OST (2002); DTI (2004); DfES (2004); OST (2003).
General: OECD S&T statistics 2004 and Main Science and Technology Indicators 2005; EC DG Competition (2005).

Figure 3 Proportion of financial effort devoted by policies types



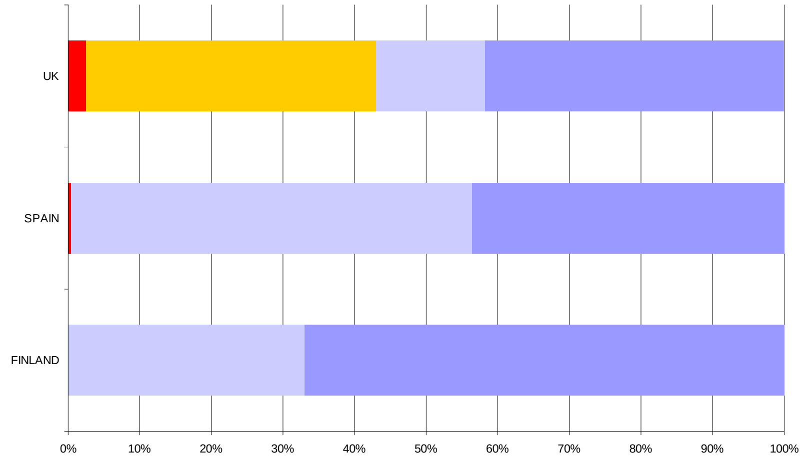
If we exclude from the analysis the support provided for the universities and public sector research centres, we can find some interesting results (see Figure 4). Firstly, the similarity between countries vanishes; the UK keeps the same proportion of market failure versus transitional systemic instruments[46], while Spain and Finland only present the latter type of measures. Secondly, if we only consider the knowledge orientation of the measures, policies in the UK and Finland are strongly oriented towards knowledge diffusion, around 80 and 65 percent respectively, while in Spain these only represent a little more than 40 percent.

Finally, we need to recall the topic of *state aid* that we mentioned in the section about typologies. The European Union, for example, establishes specific state aid rules to prevent market distortions due to governmental support of private sector activities. Figure 5 shows the comparison between the resources devoted to state aid for manufacture and services according to the EC[47] and the amount of funds oriented to industrial R&D and innovation derived from the budgets that we have been analysing. With the exception of Spain, for which we have incomplete information, the amounts are very similar, meaning that the policy instruments we have been analysing are included within state aid. The point we want to remark is that state aid rules determine that governments should only provide support to the private sector to correct market failures; and we have shown that the instruments used in the countries to promote innovation do not comply with all the market failure criteria.

46 Which perhaps could be explained due to the access to more detailed budgetary information.

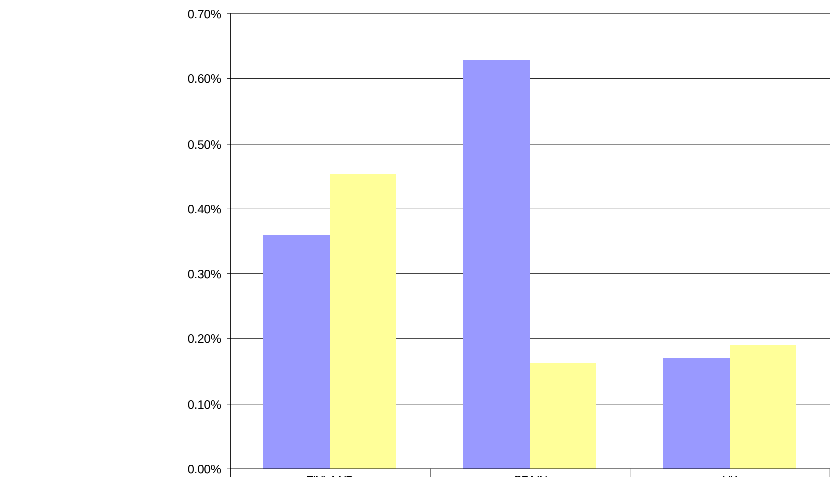
47 Data from EC DG Competition (2005).

Figure 4 Proportion of financial effort devoted to industrial R&D by policies types



	FINLAND	SPAIN	UK
TYPE VI	0.00%	0.00%	0.00%
TYPE V	66.96%	43.66%	41.74%
TYPE IV	33.04%	56.02%	15.29%
TYPE III	0.00%	0.00%	40.46%
TYPE II	0.00%	0.00%	0.00%
TYPE I	0.00%	0.32%	2.51%

Figure 5 State aid and government support to industrial R&D as % of GDP



	FINLAND	SPAIN	UK
State Aid	0.36%	0.63%	0.17%
Government support for industrial R&D	0.45%	0.16%	0.19%

6. DISCUSSION

We have suggested a typology to analyse the innovation policy mixes of countries with emphasis on their economic rationales. With it we have been able to carry out a preliminary survey of the characteristics, objectives and orientation of specific policy instruments in the selected countries. In addition, we have provided a brief description of the institutional setting for governmental support of R&D and innovation in the countries under study.

The organisation of the systems of public support in the countries included in our survey experimented important changes during the last decade. Although there are some similarities between them, each one presents specificities which have been shaped by its particular history and institutional evolution. Some of them explicitly adopt models and recommendations of organisations such as the OECD to guide their institutional design, while others only demonstrate an indirect external influence. However, the role played by these international organisations in the promotion of 'best practices' should not be neglected. This perception is reinforced by the similarities found across countries concerning the specific instruments they use to promote R&D and innovation.

Regarding the questions we asked in the introduction, our survey has shed some light on the actual rationales underlying innovation policies under concrete situations. As has been discussed the difference between them lies in the number of assumptions and restrictions they impose for the system to work, which in turn imply radically different properties and behaviours of the agents and their interactions as well as different boundaries and hierarchies between specific systems and subsystems.

We have seen that while the equilibrium approach sees policies as exogenous interventions to correct imperfections originated in the modelling limitations of the system, the systemic perspective with a wider and deeper understanding of reality sheds light to perceive that some of those alleged imperfections are in fact natural conditions of the process that is taking place. This in turn transforms policy action into endogenous control subsystems, responsible of making adaptive adjustments for the better operation of the whole system. From this we have a fundamental difference between 'fully informed' planners identifying and implementing optimal solutions to be applied horizontally in the whole economy, and 'adapting planners' fine–tuning diverse processes at various levels of the economic arena.

But despite the differences between perspectives, both models still work with the same features or processes of the economic system: the opportunities, the incentives and the distribution of resources to innovate[48]. Thus, it seems that whether we use a simple or a complex explanation of the economic process there is a pervasive problem to solve, namely that knowledge has some particular properties which affect its reproduction and diffusion in economic terms. One perspective simply recognises a failure in the system which will generally fail to produce the best possible allocation of resources for the reproduction and diffusion of knowledge. The other is able to explain that knowledge has become the most important input to the process and that some of its features are essential for the working of the economy, but that the dynamics of the system exhaust its own resources through the elimination of variety, and hence, this will hinder the generation and dissemination of new knowledge. In other words, the ultimate system failure in our economic system is the lack of capacity of the system to recursively regenerate —by means of its interactions— the network of processes that produced them[49].

Finally, from the previous reflection and despite the fact that the evolutionary–systemic approach has the potential to supersede the linear–science push vision of innovation[50] there seems that this pervasive problem around knowledge reproduction will favour a general trend towards supply–oriented policies. It also seems that the

48 Metcalfe (1995b).

49 See the notion of autopoiesis in Varela et al (1974).

50 Cf. Edquist & Hommen (1999).

current literature has not paid enough attention to this fact and this implies that in practice, in one way or another, both rationales have prescribed mainly supply oriented policies. In addition, it could be said that the evolutionary–systemic approach has not been able yet to suggest policy measures or instruments significantly different from those which have been in use for several decades.

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