STI-DUI Innovation Profiles and Implications for Innovation Policy

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1. Introduction

The objective of this paper is to analyze the measures that can be adopted in order to assess the innovation process undertaken by small and medium enterprises (SMEs) and public efforts to promote innovation among them. This responds to the challenge faced by SMEs in industrialized as production and export from cheaper economies, which is at the basis of current economic crisis, reduce their traditional market shares. The origin of this work is in the request of the Basque Government to Orkestra - Basque Institute of Competitiveness to examine the actual results of the public program for innovation promotion "Innova Empresa". This program aims at assessing SMEs in the design of new innovation strategies and new innovation plans for the short, medium and long term, and at suggesting ways that are efficient and complementary to the present ones in order to advance in the promotion of innovation among SMEs. 409 participants in the program form the empirical base for this report. These firms belong to four sectors very represented in the set of firms that went to the program: (1) machine-tools; (2) metal products; (3) paper and graphic arts, and (4) consulting, engineering and information technology firms. In this work we focus on two innovation profiles: innovation based on science and technology (STI, Science, Technology and Innovation) and innovation based on learning by doing, using and interacting (DUI, Doing, Using and Interacting) (see Jensen et al., 2007). With this objective, we group the questions and indicators provided by the program in STI and DUI indicators. The first ones reflect the absorption and transfer of codified knowledge. The second ones, on their side, reflect the "interactive" nature of innovation. The analysis shows that both STI and DUI indicators are significantly related to innovation results. This finding provides some instructions on how should public policy for innovation promotion be approached.

In the next section (2) we review literature on innovation, with special emphasis on the discussion about interactive learning as a system that can enrich the traditional innovation method focused on science and technology, based on R&D investments and patent registration. The empirical section (3) provides details on the data obtained from the information gathered by the Basque Government for this program, and the results of the statistical analysis. In the final section (4) we present implications of our results for

public policies oriented to innovation promotion in the SMEs of the Basque Autonomous Community and in other similar contexts.

2. Theoretical Developments on the Knowledge Economy

2.1 SMEs and Innovation

The importance of innovation for SMEs became very apparent with the increasing pressure withstood in the 1980s and 1990s by firms in the famous "marshallian" industrial districts (in Italy and in other countries) due to the entrance of new competitors in international markets. Already in 1992, Pyke and Segenberger identified this problem and highlighted the need of companies to move from the low stage of competitiveness to the new high stage of development. In the subsequent years, many academics insisted on the importance of this factor in different contexts, both in advanced economies (Camagni, 1991; Porter, 1998; Swann, 1998) as well as in developing countries (Kaplinsky & Readman, 2001; van Dijk & Sandee, 2002). Within this approach, competitiveness in the present globalized markets is guaranteed by innovation and quality - catalyzed through an intense cooperation through the value chain - rather than with the controversial cost and price cutting within the firm (e.g. salaries) or via suppliers and subcontractors.

This approach was rapidly incorporated to a series of public policies and programs that concentrated on creating new competitive advantages for SMEs and for local or national productive systems. It was the case of policies and programs promoting "innovator networks", "innovation systems" and "related variety platforms", among others (Lundvall, 1992; Audretsch, 2004; Cooke et al., 2004; Bianchi & Labory, 2006; Asheim et al., 2008; EU, 2008; among others). These public policy efforts underline the importance given to innovation and to innovation policies in the improvement of firm structure, including SMEs, both as individual economic units and as part of wider networks as clusters.

2.2 Innovation Factors

During the last few years, much of the debate on innovation centred on studying the types of knowledge flows that can help SMEs and big firms (specially the first ones) to absorb new inputs and transform them in relevant capacities. In this sense, different

analysis demonstrated that in different countries and production systems there are diverse organizational profiles with different models of innovation. On the one hand, there are countries that adopt the science/technology based approach that dominated studies on innovation during several decades, considering as the main inputs for innovation indicators of activities like investments in R&D, infrastructures (e.g. science and technology parks and centres) and human capital (e.g. graduates in science and technology) (Griliches, 1979; Cohen and Levinthal, 1989; Romer, 1994; Greunz, 2005). So, the most traditional innovation modes of countries like USA, Japan or Sweden are based on considerable investments in R&D and human capital. Nevertheless, it also stands out the capacity of economies like the Danish and the Italian ones to develop innovations (incremental) and to obtain better performance and economic and social development with lower investments in formal knowledge activities (Maskell, 2004).

These findings made it necessary to open the "black box" of innovation and to identify the innovation factors that focus less on the explicit knowledge flow and devote more attention to the tacit knowledge flow that generates important inputs for the global innovation process, but are difficult to measure (NESTA, 2007; Edquist et al., 2007; Cooke, 2009). Among these aspects of tacit knowledge, the interactive learning process has been identified and analyzed with increasing interest as one of the key factors. It is considered that tacit knowledge flows through interactions, through learning processes that happen by making products and processes, by using techniques and machinery, and by interacting with other social agents (DUI) (Lundvall, 1993; Lundvall & Johnson, 1994; Jensen et al., 2007).

In line with the above, Arundel et al. (2007) identified four types of organizational profiles operating in the EU, as well as the specific models of each country. These four types are: traditional organization, taylorism, lean production, and discretionary learning. Based on that, Jensen et al. (2007) also identified organizational behaviours in terms of their innovation modes and grouped them in four types: (1) low learning (that in some sense corresponds to the traditional organization identified in the previous typology); (2) STI mode; (3) DUI mode; and (4) DUI/STI mode (based on the combination of the previous two modes.

Among these four modes, the last one seems to be the best one in terms of potential of knowledge flow, learning processes and, in consequence, firm, region and country growth and development (e.g. some Nordic countries like Denmark), as the first mode (STI) contributes to more advanced scientific and technical knowledge, while the

second one (DUI) adds the possibility of spreading that knowledge among a wider audience within and between organizations, and the possibility of helping workers to absorb it in a more efficient and productive way (Jensen et al., 2007).

Regarding innovation outputs, during some decades their measurement was based on scientific/technological approaches, using patents and scientific publications as the main measurement of innovation output (Griliches, 1979; Cohen & Levinthal, 1989; Romer, 1994). During the last decades, numerous limitations to this approach were identified, among others those that emphasized that the indicators used during years represent partial indicators of the innovation process (e.g., patents are a very intermediate output of innovation). Due to these limitations, at present some alternative measurements of innovation are used as, for example, the classification: (1) new to the firm, (2) new to the national market, and (3) new to the international market (Jensen et al., 2007).

Based on the information compiled by the program Innova Empresa about innovation profiles and future innovation plans of the firms participating in the program, in the following paragraphs we measure the importance of the factors cited above (STI & DUI) in the generation of innovation outputs. The importance of understanding this relationship between different innovation inputs and outputs comes, among others, because of the relevant implications that the results of this study can have for policy makers in the Basque Autonomous Community and in other places worldwide as one of the micro tools that can help firms to come out of the current crisis and to start a restructuring of their competition mode.

3. Empirical Evidence

3.1. Sample and Methodological Approach

This analysis concentrates on 409 firms of four activity sectors with a considerable weight in the set of firms participating in the program: machine-tools, metal products, paper and graphic arts, and consulting, engineering and IT firms. They are, in general, firms of some size (31 employees on average) and turnover (except consulting, engineering and IT firms, firms in the rest of the sector had on average a turnover above four million Euros in 2007) and in some cases they export to the global market (mainly in the machine-tools sector).

Company reports prepared by consultants after meeting firm owners and/or general managers within the framework of the program Innova Empresa, which served as the basis for this study, are divided in two main parts that focus on firm profile and innovation profile. The first one focuses on key elements on corporate information such as turnover, exports and human capital, among others. The second, the most relevant one for this analysis, focuses on firms' approach to innovation. Innovation profile includes two broad areas, the first one about "innovation management" and the second one about "innovation culture". Innovation management section is divided in "innovation process" (which focuses on the process established in the firm to generate, select and develop ideas), "R&D activity", "knowledge management", "ICT management" and the existence of "tools for systematic innovation management". The second section contains information on "innovation culture", which includes systematic "training" activities, "communication", "participation" and "empowerment". Besides, a section on innovation outputs is included, thus, information on innovations carried out by the company during the last years.

The first group of indicators (innovation management) is STI type indicators. The second group (innovation culture), on its side, can also be seen in terms of STI indicators, as they refer to the existence of a systematic organization of the tools, mechanisms and procedures to promote training, participation, communication, etc. Due to the qualitative nature of the data collected in the reports, in order to analyze the information and obtain some conclusions, we extracted information from the company reports, classified it using Likert type scales and treated it quantitatively.

Once we analyzed the innovation profile of SMEs, we related it to the innovation output, which we translated from a qualitative response to the classification: (1) "No innovation" (N), (2) "new to firm" innovation (NTF), and (3) "new to market (national/international)" innovation (NTM). We analyzed the importance of STI variables for innovation output of SMEs participating in the public program Innova Empresa through contingency tables.

Then, we performed a similar analysis for the second group of variables that, following Jensen et al. (2007), we synthesized as DUI. The structure of the company reports established by the Basque Government is extremely qualitative and gives responses that the researchers had to review before assigning the grade for each company in terms of the innovation factors identified. Some variables are clearly interactive, although they could also be related to a "formal interaction" in the sense that the questions aim at

identifying whether the "innovation profile" of the firm includes interactive aspects. In some way, these variables are a mix of STI and DUI (explicit and implicit knowledge flows); our analysis does not allow us to prove that "DUI" is more important than "STI". Rather, it shows that, together with STI type factors, interaction in a wide sense is also present. In this case we also analyze if there is a relationship between firms' innovation profile, in terms of interaction, and innovation "output".

Finally, for those firms with "significant" innovation outputs, thus, firms with innovations new to the national and/or international market, we also analyze the cooperation between firms and other agents of the innovation system, especially technological centres, universities and other firms, both national or from abroad. The results of this last analysis can reinforce, correct or help to better explain the general results produced by the first block of indicators. In this way we can make a more complete interpretation of the value that STI and DUI variables have for firm performance, and, thus, help to identify the relevant implications for the program Innova Empresa and programs in other regions (in Europe and/or the rest of the world) that focus on SMEs as fundamental innovation agents.

3.2 Analysis of Results

3.2.1 STI Type Factors and their Impact on Innovation

As we explained in previous paragraphs, in this work we analyze the relationship between STI and DUI indicators and innovation outputs in small and medium enterprises in the Basque Autonomous Community that participated in the program Innova Empresa. Concretely, we analyze on the one hand "innovation management" and "innovation culture" indicators, being both groups STI type indicators, as the measure the degree of structuring or systematization of innovation in the firm, based mainly on the exploitation of codified knowledge. We grouped firms' answers in three categories: (1) a null development of the systematization of innovation management, (2) a basic effort to systematize innovation management with occasional actions and (3) an important development in the systematization of innovation management. In the following table (Table 1) we relate different levels of "innovation management" and "innovation outputs" obtained by the firms until participating in the program Innova Empresa (firms with no innovation outputs (0), "new to firm" innovations (1) and "new

to national and/or international market" innovations (2)), with the aim of analyzing whether any relationship between the two variables exists.

Table 1: Contingency Table 'Innovation Management' - 'Innovation Output'

			Management			
			1,00	2,00	3,00	Total
Innovation	0	Count	**110**	6	3	119
		% of Innovation	**92,4%**	5,0%	2,5%	100,0%
		% of total	**26,9%**	1,5%	,7%	29,1%
	1	Count	33	**169**	22	224
		% of Innovation	14,7%	**75,4%**	9,8%	100,0%
		% of total	8,1%	**41,3%**	5,4%	54,8%
	2	Count	13	7	**46**	66
		% of Innovation	19,7%	10,6%	**69,7%**	100,0%
		% of total	3,2%	1,7%	**11,2%**	16,1%
	Total	Count	156	182	71	409
		% of Innovation	38,1%	44,5%	17,4%	100,0%
		% of total	38,1%	44,5%	17,4%	100,0%

The results of the analysis show that there exists a significant relationship between "innovation management" and "innovation outputs" (level of significance .000). Then, the contingency table above shows that the great majority of firms (110 out of 119) that do not report any innovation output have a "low" (1) "innovation management" profile. Most of the enterprises that get "new to firm" innovations (169 out of 224) present a "medium" (2) "innovation management" profile. Finally, the majority of the firms with substantial or "new to national and/or international market" innovations have an "acceptable" or even an "excellent" (3) "innovation management" profile. In sum, data show that firms with greater levels of systematization in innovation management obtain greater innovation outputs.

Regarding "innovation culture", that due to the way information was collected is also included in the STI mode of innovation generation, we can observe a similar relationship between this variable and innovation outputs. A significant relationship also exists between the two variables (level of significance .000). Thus, those firms with

greater systematization of “innovation culture” get better innovation outputs. Then, the majority of firms that do not present any innovation results (62 out of 119) have a “low” (1) level of innovation culture. At the same time, the majority of the firms that get to produce “new to firm” innovations (140 out of 224) reach the “medium” (2) level in “innovation culture” profile. Finally, the majority of the firms with substantial or “new to market” innovations (28 de 66), show “acceptable” or “excellent” (3,00) “innovation culture” profiles.

Table 2: Contingency Table ‘Innovation Culture’ - ‘Innovation Outputs’

			Culture			
			1,00	2,00	3,00	Total
Innovation	0	Count	62	43	14	119
		% of Innovation	52,1%	36,1%	11,8%	100,0%
		% of total	15,2%	10,5%	3,4%	29,1%
	1	Count	39	140	45	224
		% of Innovation	17,4%	62,5%	20,1%	100,0%
		% of total	9,5%	34,2%	11,0%	54,8%
	2	Count	18	20	28	66
		% of Innovation	27,3%	30,3%	42,4%	100,0%
		% of total	4,4%	4,9%	6,8%	16,1%
	Total	Count	119	203	87	409
		% of Innovation	29,1%	49,6%	21,3%	100,0%
		% of total	29,1%	49,6%	21,3%	100,0%

In the light of these results, which show a positive and significant relationship between “innovation culture” and innovation outputs, the program Innova Empresa seems to have been right in identifying this second aspect also as central to the generation of substantial innovations in firms. These results are very relevant both to confirm the theoretical linkage between STI factors and innovation outputs, but also for public policy as it can direct resources towards those programs guaranteeing impact and efficacy.

3.2.2 DUI Factors and their Impact on Innovation

Due to the above mentioned reasons, we focus on the profiles of the firms participating in the program and also analyze the answers from a different angle: that of the informal and formal interactions that happen both within firms and between firms and other agents (other firms, technological centres, universities, etc.) to transfer explicit and tacit knowledge and to improve the performance of firms in terms of innovation this way. Because of that, from the group of variables that make up firms' innovation profile we identified those "interactive" variables, that is, the variables that best represent the tacit knowledge flows (although interaction also includes codified knowledge flows), that also contribute to the generation of innovations in the production system.

Table 3: Contingency Table 'Interaction' - 'Innovation Outputs'

			Interaction			
			,00	1,00	2,00	Total
Innovation	0	Count	78	34	7	119
		% of Innovation	65,5%	28,6%	5,9%	100,0%
		% of total	19,1%	8,3%	1,7%	29,1%
	1	Count	136	72	16	224
		% of Innovation	60,7%	32,1%	7,1%	100,0%
		% of total	33,3%	17,6%	3,9%	54,8%
	2	Count	28	24	14	66
		% of Innovation	42,4%	36,4%	21,2%	100,0%
		% of total	6,8%	5,9%	3,4%	16,1%
	Total	Count	242	130	37	409
		% of Innovation	59,2%	31,8%	9,0%	100,0%
		% of total	59,2%	31,8%	9,0%	100,0%

Table 3 relates variables "innovation output" and "interaction". As in previous analyses, in the case of innovation output we distinguish between firms that do not report

innovation outputs (0), those with some internal innovations (1) and those with substantial or relevant innovations to the national and/or international market (2). In the case of the variable “interaction”, we distinguish between firms that do not report any interaction (0), those firms that interact occasionally with other agents (1), and those with a greater interaction culture and that interact regularly (2). The analysis shows that there is a significant relationship (level of significance .001) between the interaction degree of the firm and innovation outputs. Although the degree of interaction is in general low, and there are more firms that do not interact than firms that do interact, it is in the case of the firms with better innovation output where there are higher percentages of firms that interact with others, either occasionally or regularly. Then, while 65.5% of firms that do not report any innovation outputs do not interact, almost 60% of the firms with substantial innovation output interact, 36.4% of them occasionally and 21.2% of them systematically.

As an initial interpretation and a summary of the results presented until now, we could say that “innovation management” and “innovation culture” STI elements are particularly relevant for the firms to acquire the effective ability to produce both “new to firm” innovations and, especially, “new to market” innovations. Data also show significant differences in the degree of interaction between the firms that do not innovate, the firms that carried out small internal innovations and those that produce substantial innovations for the national or international market. These data seem to confirm the importance of interaction, in addition to the traditional factor of science and technology, as a factor that can increase the efficiency of a production system through better innovation outputs (Jensen et al., 2007).

Finally, in the case of firms that obtained substantial innovation outputs during the last years, we also analyzed collaboration of these firms with other agents of the innovation system (see Figure 1).

Figure 1: Innovation in Collaboration with other Agents

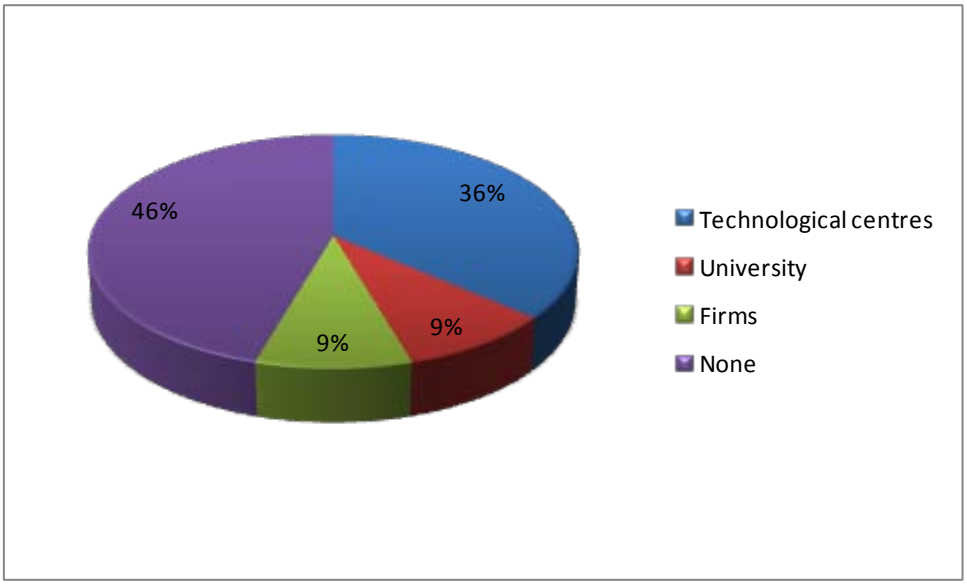

Figure 1 shows that 54% of the firms that report "new to national or international market" innovations collaborated with other agents of the innovation system. Among them, technological centres are the main agent in this collaboration. This is a very useful result, as it shows the importance of strengthening ties to exchange knowledge and competencies among agents, which enriches the firm providing it new abilities to produce substantial innovations. It is an interaction, although not as tacit/implicit/informal as the one that advocate the Nordic specialists, but a explicit one, maybe the result of a contract or a previous agreement, a "qualified interaction" that promotes the transfer/absorption of codified knowledge on the side of the firms, as it enriches them and puts them in conditions to innovate in a more consistent and radical way.

4. Conclusions and Policy Implications

This work analyzes the relationship between the innovation profile of SMEs in the Basque Autonomous Community that participated in the program Innova Empresa, and innovation outputs produced by these firms prior to their participation in the program. This analysis concentrated on the firms in four activity sectors with an important weight in the set of firms participating in the program: machine-tools, metal products, paper

and graphic arts, and consulting, engineering and IT firms. They are, in general, firms with certain dimension (31 employees on average) and capacity of generating turnover (except firms in consulting, engineering and IT activities, the rest were above four million Euros of turnover in 2007) and in some cases they export to the global market (mainly in the machine-tool sector). This means that they are not micro firms, but firms with some volume and certain capacity to face the challenges of innovation and, thus, can have concerns in line with the programs objectives, and can obtain tangible outcomes from their participation in the program.

The results of the analysis show that the program emphasized the right elements, thus "innovation management" and "innovation culture", both STI type variables, as those firms with a more structured innovation profile got better innovation outputs, both in terms of "new to firm" innovations and "new to national and/or international market" innovations. It has to be taken into account that the innovation outputs considered in this analysis are previous to firms' participation in the program. In principle, it seems natural that the participation in the program and the consultants' support should augment the impact, and that the innovation outputs in the following years could be better due to the effect of the participation in the program and the expert support provided there.

On the other hand, the study also highlights that, in this context, there is another important component of innovation processes because of its significant relationship with innovation outputs. It is the variable "interaction". Experts from Nordic countries, whose productive systems have strongly been pointing at innovation through tacit knowledge flows besides the explicit ones, already pointed out the importance of this factor (Lundvall, 1992; Jensen et al., 2007; Parrilli et al., 2010a). In particular, this analysis shows the importance of 'qualified interaction' as an explicit and tacit interaction developed with agents of the wider innovation system (not only regional, but also national and international). This aspect indicates the importance of collaboration and exchange of knowledge and competencies among agents, which could be strengthened through appropriate actions and incentives (e.g. easing information on programmes and financial incentives favouring the formulation of joint R&D projects between small firms and technology centres, excellence centres, business incubators, universities and the like).

In addition, the analysis shows a great heterogeneity among participants in the program: (1) there is a great number of firms that have not started or started in a very incipient way the process of systematizing innovation; (2) there are some groups of firms that reached certain levels in the innovation profile, which shows that a part of the firms (15-20%) have modified their work approach in order to undertake innovation activities. Among them, there are firms that developed an innovation profile more focused on the "innovation management" side and others that focused more on "innovation culture"; and (3) very few firms reached a considerable degree of systematization of innovation, with limited development of "innovation supporting tools" and "measurement and evaluation tools", two "systemic" indicators that give us a general idea on the degree of systematization of innovation. There also exist some exceptions to the limited degree of systematization of innovation, especially in consulting, engineering and IT firms, where some firms show excellent levels in terms of "innovation management" and "innovation culture". They are, in any case, a very limited group of firms, 0.5% in the first case and 5% in the second one. As the case of other systems of small firms shows (Boschma and Ter Wal, 2007; Parrilli et al., 2010b), the identification of a typology of firms could be important to identify possible steps for each of them and, probably, an improvement sequence that goes from the lowest levels to more advanced one that require measures, incentives and particular actions in order to work.

As regards innovation outputs to date, it can be seen that firms do not report high levels of performance in this aspect. Although 71% of firms (290 firms) innovated at firm level or at national and/or international level, about 30% of the firms do not report any innovation output. At the same time, the great majority of the analyzed 409 firms reports innovations at firm level (near 230 firms), which implies the introduction of products, processes or technology, organization or market innovations that help firms to sell more or better their products but do not position them as market leaders. They are, in the great majority of the cases, "follower" firms that look after introducing and/or learn gradually new technological/technical advances, organizational structures, tools and methods that are being applied in other places, and that could help them increase their productivity and competitiveness and, thus, that of their territory. A few firms show an effective capacity of generating new to national and/or international market, which is in part related to a greater systematization of innovation, in terms of "innovation management" and "innovation culture", and also to a greater formal and

informal “interactive” profile, which makes them very interesting benchmark cases for the rest of the firms that aim at developing a stronger innovation profile.

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