SCIENCE AND TECHNOLOGY POLICIES
RESEARCH CENTER

TEKPOL Working Paper Series

10/01

Patterns of Innovation and Intra-industry Heterogeneity in Turkey

Alp Eren Yurtseven
Scientific and Technological Research Council of Turkey

Sinan Tandoğan
Scientific and Technological Research Council of Turkey

TEKPOL | Science and Technology Policies Research Center
Middle East Technical University
Ankara 06531 Turkey
http://www.stps.metu.edu.tr

Patterns of Innovation and Intra-industry Heterogeneity in Turkey

Alp Eren Yurtseven [1 +], Sinan Tandoğan [1]
[1] Scientific and Technological Research Council of Turkey

Abstract. This study investigates the patterns of innovation in Turkey and its primary aim is to examine the intra – industry heterogeneity in innovative activities. For this purpose double - level factor analysis is performed and resulting factor scores are used in the subsequent cluster analyses. Four distinct innovation patterns, which may be interpreted as ingredients of different technological regimes, are identified. Taxonomy of innovative firms is also constructed by grouping firms according to their innovation characteristics and to our knowledge this is the first empirical classification study in Turkey. Our results indicate that industries differ in terms of innovative activities. However industries are not dominated by a single technological regime. On the contrary five technological regimes were observed in almost all sectors. Building upon these facts, it can be speculated that sector specific conditions determine the extent of intra – industry heterogeneity.

Keywords: Heterogeneity, firm taxonomy, sectoral innovation systems, technological regimes

You now have learned enough to see

[+] Corresponding author. Tel: +90-312-4685300 ; Fax: +90-312-4275769
E-mail Address: aeren.yurtseven@tubitak.gov.tr

The views and interpretations expressed here belong to the authors and can not be attributed to the Scientific and Technological Research Council of Turkey, its affiliated organizations or any other individual acting on behalf of these organizations.

That cats are much like you and me
And other people whom we find
Possessed of various types of mind.
For some are sane and some are mad
And some are good and some are bad
And some are better, some are worse
But all may be described in verse.
You've seen them both at work and games,
And learnt about their proper names,
Their habits and their habitat:
But how would you address a cat?
So first, your memory I'll jog,
And say: a cat is not a dog...

T.S. Eliot
Old Possum's Book of Practical Cats

1. Introduction

The main stream view of the firm depends on optimization and posits that there is only a single optimum solution. However firms operate in highly uncertain environments with often changing conditions. Hence no single best solution can be determined beforehand. In real world, boundedly rational firms depend on rules and routines in their operations. They evolve largely through local search. In addition, even firms in the same environment may opt for different strategies if their landscape is "rugged" (or complex) enough (Levinthal, 1997). That is, in a simple environment firm strategies may converge to a single solution, or global optimum. On the other hand as the complexity of operating environment increases firms may adopt different strategies, leading them to follow distinct trajectories.

Dosi (1982) defines a technological paradigm as a model and a pattern of solution of selected technological problems, based on selected principles derived from selected material technologies and argues that a technological paradigm embodies strong prescriptions on the directions of technical change to pursue and those to neglect. Once a path has been selected and established, it shows a momentum of its own. Nelson and Winter (1977) define a technological trajectory as the normal problem solving activity determined by a technological paradigm.

Despite the observed diversity in firm strategies and behavior, some regularities and patterns also emerge. Similar technological capabilities, financial incentives and constraints may shape common paths for firms. These regularities, as characterized in the concept of technological regimes by Nelson and Winter (1982), may direct the firms to organize their innovative activities in resembling ways. According to Malerba (2005) a sectoral system framework focuses on three main dimensions of sectors, which are knowledge and technological domain, actors and networks, and institutions. Sectoral innovation system approach depends on the idea that firms nested in a sector behave in correlated ways since they share sources of information and technology and perceive similar incentives for innovation.

Pavitt's (1984) influential study provides a holistic approach on how technological regimes emerge in different industries. Pavitt compared and classified industries according to the sources of technology used in the innovation process, nature of the developed technology, sectors in which these innovations were adopted and firm level characteristics such as size and principal activity. Using these variables Pavitt constructed his taxonomy and identified four distinct groups in manufacturing industries: 1) supplier dominated, 2) scale intensive, 3) specialized suppliers, 4) science based sectors (ibid). In their later work, Pavitt et. al. (1989) modified the original taxonomy by introducing a new category – information intensive sectors, as a substitute to the supplier dominated sectors.

Following this strand of research, Malerba and Orsenigo (1995) put forward taxonomy of innovative patterns with respect to the learning patterns of firms over time. Malerba and Orsenigo (1996) argue that their sectoral classification based on Schumpeter's Mark I and Mark II models should be able to identify most technological classes. Audretsch (1997) states that the most important factor shaping the evolution of firms belonging to a specific industry is the knowledge condition shaping the technological regime underlying that industry. Studying the data gathered from 24.000 business units in Italy, Archibugi et al. (1991) propose a new taxonomy of sectors, based on industrial concentration, propensity to develop product vs. process innovations, and the sources of technological change, arguing that sectoral differences are most influential in the explanation of technological change. Klevorick et al. (1995) build upon the concept of technological opportunity to explain inter - industry differences and conclude that inter – industry differences in the strength and sources of technological opportunities contribute importantly to explanations of cross – industry variation in R&D intensity and technological advance. Studying the characteristics of 105 Greek manufacturing firms, Soutaris (2002) argues that important determinants of innovation differ in industries according to four classes of Pavitt's taxonomy. Although empirical methodology and measurement of concepts may vary in these studies a common finding emerges: Industries differ with respect to firms' innovation behavior and these differences matter for industry structure and innovativeness. In addition, despite the emphasis on bounded rationality and heterogeneity of firms in their operations, this literature depicts a firm, of which innovative behavior is largely industry specific. Each system needs to be defined by boundaries (Edquist, 2005). However aforementioned studies have not validated whether industry boundaries truly define the boundaries of technological regimes.

In his later work Archibugi (2001) argues that technology based taxonomy of firms loses much of its relevance, if it is applied to firms after they have been aggregated into industries according to an output based classification. In this sense, Arvanitis and Hollenstein (1997) use firm level data on Swiss manufacturing and identify five different innovation modes, which have low correspondence to industrial affiliation. With a similar approach Hollenstein (2003) performs a cluster analysis on firm level data to identify innovation modes in Swiss service sector. Hollenstein identifies five distinct innovation modes and concludes that a classificatory procedure based on firm level data is more appropriate than an approach which ranks industries according to their innovativeness (ibid). de Jong and Marsili (2006) focus on small and micro firms in the Netherlands and they report the existence of four categories of small innovating firms dispersed in various sectors. Leiponen and Drejer (2007) compare the innovation patterns of Finnish and Danish firms and identify similar groups, of which categories exceed specific industries. Srholec and Verspagen (2008) use firm level data from 13 different countries to assess the heterogeneity of innovation process. They identify four innovation patterns and claim that sectors and countries matter to a certain extent in explaining the heterogeneity of innovation process, but far most of the variance is given by the heterogeneity of firms within either sectors or countries (ibid). Not all these studies explicitly aim to test the relevance of sectoral patterns by a quantitative analysis. However their findings indicate that innovation patterns (or modes), which are not confined to specific industries exist. Moreover these studies show that firms can display a variety of these patterns with different intensities, which can be articulated as exploration and exploitation may occur simultaneously within the firm.

This study investigates the patterns of innovation in Turkey and its primary aim is to examine the intra – industry heterogeneity in innovative activities. A taxonomy of innovative firms is also constructed using firm level data, and to our knowledge this is the first empirical study in Turkey to quantitatively group firms according to their innovative behavior. This taxonomy can be used to assess the industry specific innovative behavior of firms. The limits of industrial homogeneity in terms of innovative activities have a bearing on technology policies. Public incentives towards high – tech industries may not create the expected impact, since a considerable amount of firms in that industry may have different innovative characteristics than the industry perception or they may not be innovative at all. On the contrary firms in traditionally low – tech sectors may in fact be highly innovative. A better understanding of the dynamics of innovation process at the firm level is necessary to design and implement adequate and efficient technology policies. In addition, acknowledgment intra – industry heterogeneity in innovation behavior may also affect the course of scholar research on dynamics of innovation. The rest of this paper is organized as follows: Next section introduces the data set used in this study and explains the empirical methodology used in the analysis. Section 3 identifies and interprets innovation patterns found at the firm level, and examines their correspondence with industrial affiliation. Section 4 concludes the paper with an overview of the significance (and limitations) of the findings. Possible effects of acknowledging intra – industry heterogeneity is also discussed in this section.

2. Data and Methodology

Analysis in this study is based on the firm level data from Turkish Community Innovation Survey – 2006, provided by Turkish Statistical Institute (TURKSTAT). Following the 3rd edition of the Oslo Manual, a harmonized questionnaire was used to collect data. First section of the questionnaire is designed to gather general firm characteristics like the legal title, foreign share, annual turnover, average number of employees, and the markets in which the firm is active. Section 2 and 3 are devoted to questions regarding product and process innovations. Questions in sections 5, 6, and 7 are directed only to innovating firms[1]. Variety and amount of innovation expenditures, sources of knowledge, institutional and spatial characteristics of cooperation, and the impact of innovative activities are reported in these sections respectively. Section 8 collects data about halted and abandoned innovation projects in addition to an assessment of barriers to innovation, whereas section 9 gathers data about the variety of intellectual property rights protection methods pursued by firms. The last section, which has been integrated to the survey

[1] Firms that have introduced a product or process innovation, or having an abandoned or ongoing innovation project are defined as "innovative" in the survey.

according to the recommendations in the 3rd edition of the Oslo Manual, is related to organizational and marketing innovations. The survey provides information about 2.173 firms, of which 780 are considered to be innovative. Industrial affiliations of firms according to NACE Rev. 1.1 classification are presented in Table 1[2].

Table 1 Sectoral distribution of firms in Turkish CIS 2006

NACE	Industry	All Firms		Innovative Firms	
		N	%	N	%
10-14	Mining and quarrying	147	6.76%	37	4.74%
15-16	Food, beverages, and tobacco	114	5.25%	51	6.54%
17-19	Textiles, wearing, apparel, and leather	286	13.16%	88	11.28%
20-22	Wood, pulp, paper, printing, publishing	42	1.93%	20	2.56%
23-25	Petroleum, chemicals, rubber, and plastic products	94	4.33%	43	5.51%
26-28	Metals, metallic and non-metallic mineral products	149	6.86%	66	8.46%
29,34,35	Machinery and equipment n.e.c. Transport equipment	126	5.80%	67	8.59%
30-33	Electrical and optical equipment	41	1.89%	21	2.69%
36-37	Manufacturing n.e.c.	40	1.84%	20	2.56%
40-41	Electricity, gas, and water supply	132	6.07%	38	4.87%
51	Wholesale trade and commission trade	350	16.11%	108	13.85%
60-63	Land, water, and air transport	218	10.03%	48	6.15%
64-67	Telecommunications, financial intermediation	163	7.50%	75	9.62%
72-74	Computer and related activities, architectural and engineering activities, and related consultancy	271	12.47%	98	12.56%
	Total	**2173**	**100.00%**	**780**	**100.00%**

Innovation is a complex phenomenon, thus a firm's innovation strategy is expected to have multiple dimensions. Although earlier studies mainly focused on R&D spending (or R&D intensity) and patent counts as the main input and output indicators of a firm's innovative behavior (Hagedoorn and Cloodt, 2003), availability of CIS data made it possible to carry out detailed studies related to the determinants of innovation behavior of firms. As shown in Table 2, various variables can be used to describe the relevant dimensions of the innovation process. This study aims to discover the patterns of innovation in Turkish firms with a sense that a number of latent variables may exist, which can be used to form a multi-dimensional framework. Factor analysis, which is a multivariate statistical method, can be used to extract these latent variables from a large number of seemingly unrelated variables. Factor analysis is used to describe variability among observed variables in terms of fewer unobserved variables called factors[3]. The observed variables are modeled as linear combinations of the factors, plus error terms. The information gained about the interdependencies can be used later to reduce the set of variables in a dataset. Factor analysis has many applications in psychology and other social sciences, and recently it has been employed in a number of studies on the dynamics of innovation (Firm level

[2]Sampling weights, which are developed using industry affiliations together with firm size distributions, are used in the subsequent factor analyses.

[3] An exact quantitative basis for deciding the number of factors to retain has not been developed. Hair et. al. (1998) suggest a number of stopping criteria, one of which is percentage variation criterion. This approach is based on achieving a specified cumulative percentage of total variance extracted by successive factors. 75% and 50% percent threshold values have been used in the first and second level factor analyses respectively.

studies: Hollenstein, 2003; Leiponen and Drejer, 2007; Srholec and Verspagen, 2008; Fraga et. al., 2008; Zizalova, 2009; Country level studies: Fagerberg et. al., 2007; Fagerberg and Srholec, 2008).

Following Srholec and Verspagen (2008) a two – level factor analysis is performed on the variables shown in Table 2. In the first stage, factor analysis is separately performed on the variable groups listed in Table 2. Factor scores obtained from the previous stage are used in the second stage factor analysis. Principal component factors method is used for factor extraction, since it does not depend on any distributional assumptions. Rotation of extracted factors is necessary for interpretation. Oblimin rotation, which is a variant of oblique rotation methods that allow for correlation of extracted factors, is used in the process. Factor analysis should be run on continuous variables, or ordinal variables with broad ranges to allow for identifying reasonable covariance matrices (Hair et. al., 1998). Since our data set consists of binary and narrowly scaled ordinal variables, polychoric correlation matrices, as suggested by Kolenikov and Angeles (2004), are fed to the factor analyses with the assumption that ordinal variables listed in Table 2 reflect underlying continuous variables.

Table 2 Variables used in the first stage factor analyses

	Variable	Description	Scale
Variety of innovation activities	RDIN	Internal R&D	Binary
	RDOUT	Acquisition of extramural R&D	Binary
	INMACH	Acquisition of machinery and equipment	Binary
	INIPR	Acquisition of external knowledge	Binary
	INEDU	Training and education	Binary
	INMAR	Market introduction of innovations	Binary
	INOTHER	Other innovation activities	Binary
Variety of information sources	INFSOURCE1	Within enterprise	0-3
	INFSOURCE2	Equipment and software providers	0-3
	INFSOURCE3	Clients	0-3
	INFSOURCE4	Competitors in the same sector	0-3
	INFSOURCE5	Private R&D firms, commercial labs.	0-3
	INFSOURCE6	Universities	0-3
	INFSOURCE7	Public R&D institutes	0-3
	INFSOURCE8	Fairs and exhibitions	0-3
	INFSOURCE9	Scientific journals, sectoral bulletins etc.	0-3
	INFSOURCE10	NGOs	0-3
Variety of firm level impacts of innovation	IMP1	Increased range of goods and services	0-3
	IMP2	Increased domestic market share	0-3
	IMP3	Increased foreign market share	0-3
	IMP4	Improved quality in goods and services	0-3

	IMP5	Improved production and service flexibility	0-3
	IMP6	Increased production capacity	0-3
	IMP7	Reduced labor costs	0-3
	IMP8	Reduced energy and material consumption	0-3
	IMP9	Environmental and health safety aspects	0-3
	IMP10	Met standards and/or regulations	0-3
Variety of non-technological innovations	ORG1	Installing a new management information system	Binary
	ORG2	Significant changes in firm's organizational structure	Binary
	ORG3	New or improved methods in collaborative activities	Binary
	ORG4	Significant changes in product design or packing	Binary
	ORG5	Application of new or improved marketing and/or distribution methods	Binary
Variety of IPR protection methods	IPR1	Patent registration	Binary
	IPR2	Industrial design registration	Binary
	IPR3	Trademark registration	Binary
	IPR4	Copyright registration	Binary

In the next step factor scores obtained from the second stage factor analysis are input in a k - means cluster analysis with the aim of grouping the firms into distinct categories, which are as homogenous as possible with respect to the factor dimensions. Instead of iteratively classifying firms based on their distance to some initial starting points of the factor dimensions, centroids of an initial hierarchical solution are used for this purpose as suggested by Punj and Stewart (1983). Finally, the distribution of firms within each industry across the obtained clusters is examined to assess the industry specific dynamics of innovation.

3. Empirical Analysis

First stage factor analyses start with the variation of firm's innovation activities. As can be seen in Table 3, three factors emerge: design and marketing, research and development, and technology transfer. Our findings indicate that complementary activities, such as training of staff and preparatory activities pertaining to marketing of innovations play a dominant role in firms' innovation strategies. Moreover research and development factor indicates that in - house R&D and extramural R&D complement each other. The third factor indicates that innovative firms depend on both embodied and disembodied technology transfer, either by means of machinery and equipment acquisition or licensing.

Table 3 Factor analysis on variety of innovation related spending

Variable	**(1) Design&Marketing**	**(2) R&D**	**(3) Technology Transfer**
RDIN	0.2435	0.7845	-0.1140
RDOUT	-0.0159	0.7733	0.2574
INMACH	-0.0648	0.2749	0.7817
INIPR	0.2666	-0.1128	0.8096
INEDU	0.7907	-0.0837	0.2720
INMAR	0.8193	0.1139	0.0336

INOTHER	0.9104	0.1207	-0.1105

Three factors explain 80.70% of total variation. Number of observations: 780

Factor analysis on the sources of information used in the innovation process also yields three dimensions: information from scientific institutions, NGOs and events, and clients and competitors. The most dominant factor, information from scientific institutions, combines private R&D laboratories, universities, and public research institutions. The second principal component puts together NGOs, fairs and exhibitions, and scientific journals as the sources of information used in the innovation process. The third principal component connects information from machinery and equipment suppliers, competitors and clients in addition to firm's own sources.

Table 4 Factor analysis on variety of information sources

Variable	(1) Information from Science	(2) Information from NGOs & Events	(3) Information from Clients & Competitors
INFSOURCE1	0.0315	-0.1314	0.7846
INFSOURCE2	0.0255	0.1038	0.7374
INFSOURCE3	0.0039	0.2554	0.6719
INFSOURCE4	0.1842	0.1110	0.5867
INFSOURCE5	0.7606	0.0396	0.2013
INFSOURCE6	0.9167	0.0556	-0.0028
INFSOURCE7	0.9540	-0.0302	0.0206
INFSOURCE8	-0.1520	0.8644	0.2112
INFSOURCE9	0.0696	0.8562	0.0684
INFSOURCE10	0.3073	0.7821	-0.1671

Three factors explain 75.30% of total variation. Number of observations: 780

Results of the factor analysis on the impacts of innovation are reported in Table 5. Three dimensions emerge, which have been identified as process related effects, product related effects, and regulation conformance. Our results indicate that Turkish firms are more oriented towards process innovations, rather than new product development. Especially reduced labor cost and reduced energy and material consumption variables load highly on the first principal factor. Thus it can be argued that Turkish firms seek to gain competitiveness by reducing their production costs. In addition, high correlation of increased production capacity and improved production and service flexibility variables indicates that Turkish firms opt to direct their innovative efforts to capacity stretching. Moreover these factors also have slight loads on the second principal factor, indicating that product and process innovations usually accompany each other. Regulation conformance also emerges as an important outcome of innovative activities, which can be interpreted as a reflection of structural changes in Turkish legislative system due to the European Union accession process.

Factor analysis on the impacts of non – technological innovations clearly distinguishes organizational and marketing innovations, whereas a single factor describes the variety of intellectual property rights protection activities. Results of these factor analyses are presented in Tables 6 and 7 respectively.

Table 5 Factor analysis on innovation effects

Variable	(1) Process Related Effects	(2) Product Related Effects	(3) Regulation Conformance
IMP1	-0.0244	0.8322	0.0411
IMP2	0.1901	0.8046	-0.1112
IMP3	-0.0622	0.7575	0.0040
IMP4	0.1108	0.5780	0.3407
IMP5	0.6334	0.2600	0.0736
IMP6	0.6634	0.2405	0.0886
IMP7	0.9323	-0.0838	0.0351
IMP8	0.9091	-0.0566	-0.0165
IMP9	0.0761	-0.0326	0.9146
IMP10	-0.0239	0.0094	0.9703

Three factors explain 76.25% of total variation. Number of observations: 780

Table 6 Factor analysis on non – technological innovations

Variable	(1) Organizational	(2) Marketing
ORG1	0.9120	-0.0040
ORG2	0.8003	0.1341
ORG3	0.7917	-0.0611
ORG4	-0.0754	0.9672
ORG5	-0.1312	0.8240

Two factors explain 76.97% of total variation. Number of observations: 780

Table 7 Factor analysis on IPR protection methods

Variable	(1) IPR
IPR1	0.9295
IPR2	0.8299
IPR3	0.9058
IPR4	0.8869

Single factor explains 79.00% of total variation. Number of observations: 780

Factor scores obtained from these analyses are fed into the second stage factor analysis in order to identify distinct innovation approaches. As shown in Table 8, four principal components, which can be interpreted as diverse innovation patterns, emerge. The first principal component is designated as "networked R&D". Both R&D and design & marketing in addition to other dimensions describing the sources of information have high loadings on this factor. Moreover this pattern also includes organizational innovation and cooperation to a limited extent. It can be argued that "networked R&D" component describes the often mentioned research based innovation concept. The second innovation pattern is termed as "production intensive" since process related effects of innovation and regulation conformance, which basically determine process technologies, have high loadings on this principal component. Firms following this path are also active in new product development. In addition organizational innovation and cooperation also have a bearing on this principal component. "Market driven" pattern brings together marketing innovation and IPR dimensions in addition to organizational innovation and product related effects of innovation. R&D and design & marketing have slight loadings on this principal component. The last principal component is designated as "external oriented" since it combines technology transfer and cooperation. Moreover firms following this pattern are highly sensitive to protecting their intellectual properties through various methods.

Table 8 Results of the second stage factor analysis and patterns of innovation

Variable	(1) Networked R&D	(2) Production Intensive	(3) Market Driven	(4) External Oriented
Design & marketing	0.5083	0.0628	0.2679	0.0748
R&D	0.4393	-0.0307	0.1650	0.0534
Technology transfer	0.0098	0.1069	0.0134	0.7970
Info. from science	0.7665	-0.0946	-0.1782	0.1187
Info. from NGOs and events	0.7740	0.0044	-0.0303	-0.1390
Info. from clients and competitors	0.5397	0.2623	0.0557	-0.0104
Process related effects	0.0042	0.8094	-0.006	0.1152
Product related effects	0.1198	0.5668	0.3103	-0.0981
Regulation conformance	-0.0830	0.8316	-0.0592	0.0617
Organizational innovation	0.2239	0.2927	0.4061	-0.1181
Marketing innovation	0.0415	0.1106	0.7695	-0.0501
IPR	-0.0546	-0.1746	0.5804	0.4954
Cooperation	0.2636	0.2707	-0.1433	0.4522

Four factors explain 54.17% of total variation. Number of observations: 780

As explained in the previous section second level factor scores are fed into the cluster analysis, of which aim is to form as homogenous as possible groups of firms with respect to their innovation characteristics. These clusters can also be viewed as reflections of underlying technological regimes. In the first step a hierarchical cluster analysis is performed. As can be seen in the resulting dendogram (Figure 1), five branches can be easily located. Centroids of groups formed through hierarchical cluster analysis were used as initial starting points for k-means cluster analysis. Mean factor scores for these five clusters formed through k-means clustering are shown in Table 9.

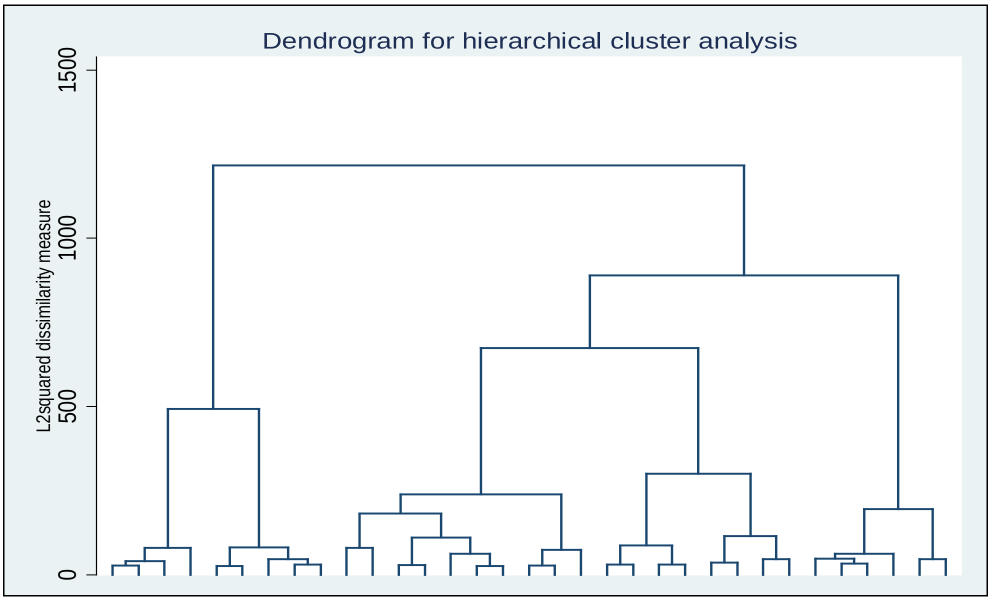

Figure 1 Dendogram for hierarchical cluster analysis

Table 9 Clusters of innovation characteristics / technological regimes

	High profile innovators	Market oriented innovators	Production intensive innovators	External oriented innovators	Low profile innovators
Networked R&D	1.542	-0.181	-0.042	0.694	-0.804
Production intensive	0.814	0.090	0.623	0.367	-1.160
Market driven	0.637	0.928	-0.846	0.368	-0.679
External oriented	-0.331	-0.424	-0.292	1.979	-0.233
Average employee	180.69	61.81	66.96	95.58	51.16
Innovation investments/sales (%)	7.41	3.44	5.84	11.30	2.94
Product innovation (%)	91.44	73.74	64.07	74.14	60.95
Process innovation (%)	82.82	73.25	82.16	87.79	49.29
Share of novel products in total sales	26.11	31.77	20.45	20.88	16.84

High profile innovators have above average scores in all factors, except the external oriented dimension[4]. It can be argued that firms in this group tend to benefit from various information sources, but they mainly depend on R&D and complementary innovative activities to develop new products or processes. Firms in this group have the highest average employee figure, which conforms to the idea that larger firms are more active in innovation. High profile innovators, which are active in both product and process innovations, have the second highest innovation investment over sales ratio.

Highest sale share of novel goods and services is encountered in the market oriented innovators group. Firms in this group are also active in both product and process innovations. On the contrary, firms in the production intensive innovators group are keener to process innovations. It can be argued that this group is populated with firms, which seek advantage through cost reductions and efficiency increases. External oriented innovators group has above average scores in all dimensions, but principal component pertaining to technology transfer and

[4] Factor scores have a zero mean and unit standard deviation. Consequently an average score above zero indicates bias towards the corresponding factor in that cluster.

cooperation is very dominant. Moreover firms in this group have the highest innovation expenditure over sales ratio. A bias towards process innovation is also observed in this group. Consequently it can be argued that firms in this cluster depend on embodied and disembodied forms of technology transfer to upgrade their production infrastructure. Furthermore above average score in the networked R&D component indicates that acquisition of extramural technology is complementary to the in – house innovative activities of the firms in this group.

Distribution of clusters over industries is shown in Figure 2. As mentioned above, clusters based on the identified innovation patterns are viewed as reflections of underlying technological regimes. In this sense, an industry is assumed to be dominated by a specific technological regime, if the share of related cluster exceeds 50% in that industry. Our results show that such dominance is observed only in "electricity, water, and gas supply" industries (NACE code 40-41). Approximately 66% percent of firms in these industries belong to the "production intensive" cluster, whereas "market oriented" firms are not represented in these industries. "High profile innovators" exist in all sectors, except wood, pulp, paper, printing, and publishing industries (NACE code 20-22). High profile innovators are most common in electrical and optical equipment (~24%), and petroleum, chemicals, rubber, and plastic products industries (~23%). However high profile innovators do not constitute the majority in any industry. Low share of high profile innovators, which is predominantly based on the "networked R&D" component, indicates that R&D is an important, yet one of many aspects of the innovation process.

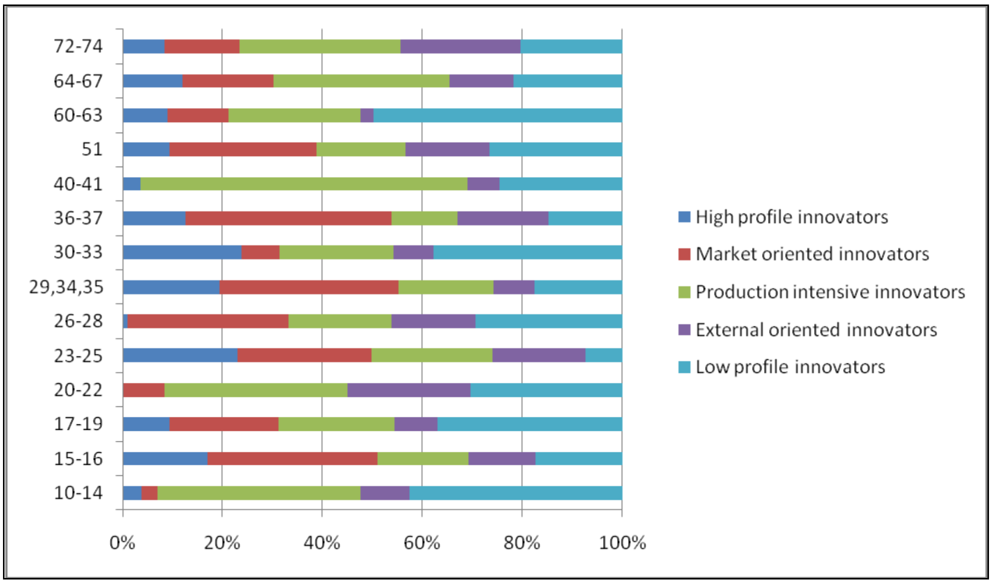

Figure 2 Distribution of clusters over industries

Although not statistically tested, it is apparent from Figure 2 that industries differ with respect to the concentration of clusters. However importance of intra – industry heterogeneity in terms of innovation characteristics should not be underestimated, since these five clusters are observed in almost all sectors. Characteristics of knowledge base, experience accumulation and learning processes, and the working of dynamic complementarities may create sector specific conditions. It can be argued that sector specific conditions affecting variety creation, replication, and selection may shape the composition of an industry with respect to technological regimes. However these sectoral differences do not align firms in specific industries to similar paths, but determine the extent of intra – industry heterogeneity.

4. Conclusion

This paper presented a study on determination of innovation patterns and an analysis of intra – industry heterogeneity. For this purpose factor analyses were performed in two stages. Resulting principal components were identified as distinct innovation patterns. These patterns were recognized as ingredients of different technological regimes, thus a cluster analysis was performed to form as homogenous as possible groups in terms of innovation behavior. Cluster analysis yielded five distinct groups of firms. These groups were viewed as the reflections of underlying technological regimes. High profile innovators represent the idea of research based innovation, but this group does not constitute the majority in any industry. Both internal and extramural R&D are important ingredients of innovation. However innovation is a complex and multi – dimensional phenomenon, which transcends R&D alone. Consequently public policies aiming to foster innovation should be designed to cover other aspects as well.

External oriented innovators have above average scores in all innovation patterns, but they are mainly characterized by acquisition of external technology and cooperation. Our findings indicate technology transfer and internal R&D complement each other. Within a developing country context it can be argued that firms in this group acquire external technology, combine it with their existing knowledge stock and R&D efforts, and then develop new products and processes. This process generally takes more time for the firms in developing countries before they become innovators and as Beyhan et al. (2010) argued, innovation measurement in these countries should also include "potentially innovative" firms.

Market oriented innovators have the highest share of novel products in their sales and they are active in both product and process innovations. On the other hand production intensive innovators are biased towards process innovations. It can be argued that production intensive innovators seek to gain advantage through cost reductions and efficiency increases. Low profile innovators have below average scores in all four innovation patterns. Moreover they have the lowest innovation investment over sales ratio. Depending on our results it can be speculated that their innovative activities are carried out on an ad-hoc basis. As can be seen in Table 9, this group consists of smaller firms in terms of average employee number. Low innovative activity in this group may be attributed to the idea that a firm's perception of its innovation environment largely depends on its size (Arundel, 2001).

Sectoral innovation system approach suggests that heterogeneous firms with similar technologies, searching around similar knowledge bases, undertaking similar production activities, and embedded in the same institutional setting, share some common behavioral and organizational traits and develop similar range of learning patterns, and organizational forms (Malerba, 2005). Malerba acknowledges the importance of intra-industry heterogeneity and addresses its extent and features as a potential research area (ibid). Our results and other empirical studies (Leiponen and Drejer, 2007; Srholec and Verspagen, 2008) show that most industries are populated by firms with very different innovation characteristics. Our results indicate that industries differ in terms of innovative activities. However industries are not dominated by a single technological regime. On the contrary five technological regimes were observed in almost all sectors. Building upon these facts, it can be speculated that sector specific conditions determine the extent of intra – industry heterogeneity.

Firms continuously interact with each other and their environment, rather than being atomistic entities. Our study identified five types of firms under different technological regimes. However their interactions with each other remain to be unveiled. Moreover, innovation patterns, thus technological regimes are dynamic and their evolution in time should also reveal valuable insights about the innovative behavior of firms.

Sectoral policies should acknowledge the elements that make apparently similar firms different, rather than seeking the same traits in firms since sectors are not homogenous in terms of the innovation characteristics of the firms they contain. Consequently, sectoral taxonomies of innovation based on aggregated data may be even less relevant. Policies should be designed to address the needs and potential of different firms without overlooking their distinctive characteristics.

Acknowledgements

We would like to thank the Scientific and Technological Research Council of Turkey for supporting this study and TURKSTAT for kindly providing us the Turkish CIS – 2006 data.

References

Archibugi, D., Cesaratto, S., Sirilli, G. (1991) Sources of innovative activities and industrial organisation in Italy. Research Policy 20, 357-368

Archibugi, D. (2001) Pavitt's taxonomy sixteen years on: A review article. Economics of Innovation and New Technology, 10, 415-425

Arundel, A., (2001) The relative effectiveness of patents and secrecy for appropriation. Research Policy 30, 611–624

Arvanitis, S., Hollenstein, H. (1997) Innovative activity and firm characteristics - a cluster analysis with firm-level data of Swiss manufacturing. 25th Annual Conference of the European Association for Research in Industrial Economics. Copenhagen, Denmark

Audretsch, D.B., (1997) Technological regimes, industrial demography and the evolution of industrial structures. Industrial and Corporate Change 6, 49–82

Beyhan, B., Dayar, E., Fındık, D., Tandoğan, S. (2010) Comments and critics on the discrepancies between the Oslo Manual and the community innovation surveys in developed and developing countries. METU STPS Working Paper No:0903

de Jong, J.P.J., Marsili, O. (2006) The fruit flies of innovations: A taxonomy of innovative small firms. Research Policy, 35, 213-229

Dosi, G., (1982) Technological paradigms and technological trajectories: A suggested interpretation of the determinants and directions of technical change. Research Policy 11, 147–162

Edquist, C. (2005) Systems of innovation: perspectives and challenges. In: Fagerberg, J.,Mowery, D., Nelson, R. (Eds.), Oxford Handbook of Innovation. Oxford University Press

Fagerberg, J., Srholec, M., Knell, M. (2007) The competitiveness of nations: Why some countries prosper while others fall behind. World Development, 35, 1595-1620

Fagerberg, J., Srholec, M. (2008) National innovation systems, capabilities and economic development. Research Policy 37, 1417-1435

Fraga, M., Martins, O., Anciaes, P. (2008) Patterns of innovation diffusion and technological competition in Portuguese manufacturing and service industries.International Review of Applied Economics 22, 353-372

Hagedoorn, J., Cloodt, M. (2003) Measuring innovative performance: Is there an advantage in using multiple indicators? Research Policy 32, 1365-1379

Hair, J.F., Anderson, R.E., Tatham, R.L., Black, W.C., (1998) Multivariate Data Analysis, fifth ed. Prentice Hall, Englewood Cliffs, New Jersey

Hollenstein, H. (2003) Innovation modes in the Swiss service sector: a cluster analysis based on firm-level data. Research Policy, 32, 845-863

Klevorick, A.K., Levin, R.C., Nelson, R.R., Winter, S.G., (1995) On the sources and significance of inter-industry differences in technological opportunities. Research Policy 24, 185–205

Kolenikov, S., Angeles, G. (2004) The use of discrete data in principal component analysis with applications to socio-economic indices. CPC/MEASURE Working paper No. WP-04-85

Leiponen, A., Drejer, I. (2007) What exactly are technological regimes? Intra-industry heterogeneity in the organization of innovation activities. Research Policy, 36, 1221-1238

Levinthal, D.A., (1997) Adaptation on rugged landscapes. Management Science 43 7, 934–950

Malerba, F., Orsenigo, L. (1995), Schumpeterian patterns of innovation, Cambridge Journal of Economics, 19, 47–65

Malerba, F., Orsenigo, L., (1996) The dynamics and evolution of industries. Industrial and Corporate Change 5, 51–87

Malerba, F. (2005) Sectoral systems: How and why innovation differs across sectors. In: Fagerberg, J.,Mowery, D., Nelson, R. (Eds.), Oxford Handbook of Innovation. Oxford University Press

Nelson, R., Winter, S. (1977) In search of a useful theory of innovation. Research Policy 6, 36-76

Nelson, R.R., Winter, S.G., (1982) An Evolutionary Theory of Economic Change. Harvard University Press, Cambridge

Pavitt, K., (1984) Sectoral patterns of technical change: towards a taxonomy and a theory, Research Policy, 13, 343–373

Pavitt, K., Robson, M., Towsend, J. (1989) Technological Accumulation, Diversification and Organisation in UK Companies, 1945-1983. Management Science 35, 81-99

Punj, G., Stewart, D.W., (1983) Cluster analysis in marketing research: review and suggestions for application. Journal of Marketing Research 20, 134–148

Souitaris, V. 2002. Technological trajectories as moderators of firm-level determinants of innovation. Research Policy, 31, 877-898

Srholec, M., Verspagen, B. 2008. The voyage of the Beagle in innovation systems land. Explorations on sectors, innovation, heterogeneity and selection. UNU-MERIT Working Paper Series, 2008-008

Zizalova, P. (2009) Economics And Management Of Innovation, Technology And Organizational Change. DRUID-DIME Academy Winter 2009 PhD Conference, Aalborg, Denmark