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Sectoral system of innovation and sources of technological change in machinery industry: an investigation on Turkish machinery industry[a]

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Abstract

Machinery industry is the main sector in investment product sector. Therefore it has an strategic importance. Turkish machinery industry must have a technology policy to achieve competitiveness on a global level. This study, focus on the sectors which can produce and transfer technology and knowledge. Thus it is based on the basis of the sectoral system of innovation which can produce industry specific technology. In this study according to innovation activities 250 different scale firms data were collected using a questionnaire prepared by the Oslo Manual. Data were analyzed. And the results obtained from the data used for researching the level of technological capabilities of the sectors. Finally the sector's position in new technological developments such as Industry 4.0 was evaluated.

JEL: O31, O32, R11

Keywords: Sectoral System of Innovation, Industry 4.0, Turkish Machinery Industry

1. Introduction

Machinery industry is the essential sector producing investment goods among the industrial sectors and thus has a strategic importance. In this context, the machinery industry is an industry which is given importance by the most advanced economies and is a branch of industry which is identified as a privileged sector. Turkish

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machine sector is one of the locomotive sectors of our manufacturing industry. The importance of the locomotive role undertaken in the economy is shown by the fact that it provides inputs into almost all sectors of the manufacturing industry, that it is the driving force of the sectors, that has parallels with the development of the manufacturing industry, that the discipline of engineering is mobilized and that the designation of the development speed and production compositions according to the new needs and demands (Bayülken, 2012). In the classification made according to NACE Rev2, the sub-branches of "The manufacturing of machine and equipment not elsewhere classified" are the manufacture of general purpose machinery, manufacture of other general purpose machinery, manufacture of agricultural and forestry machinery, manufacture of metal processing machinery and machine tools and manufacture of other special-purpose machinery. Considering the manufacturing industry, one of the factors determining the added value generated by the manufacturing industry is in which technological level the sector activates is included. According to the technological classification made by OECD according to the R&D (Research & Development) intensity in the machinery industry is in the medium-high technology group. Machinery industry includes both the machinery as capital goods and the companies that produce parts and components in the production of these machines. Intermediate products as such bearings, gears, valves, fluid equipment and motors constitute approximately one third of machine sector productions. Many of these products are submitted to the other firms operating in the machine sector. Among the other sectors purchasing intermediate products from machinery sector are the electricity sector, automotive sector, medical equipment sector and other precision instruments sector. In the present time, it can be observed that the states apply such industrial policies which have strategic objectives for the development of the sector when the experiences of such countries as Germany, North Korea and Japan which have developed machinery industries is investigated. Machinery industry is accepted as one of the sectors having strategic importance in the new Turkish Industrial Strategy Document announced in the beginning of 2011 year. The main vision of the sector announced later in the "Turkish Machinery Sector Strategy Document" is specified as "Being a Technological Production Base in Machinery Sector" (T.R. Ministry of Science, Industry and Technology, 2011; 2014). There is a need for a technology policy taking into account the technological development dynamics of the sector in order to be able to reach this vision. The object of this study are investigating the processes of R&D and innovation in the Turkish machinery industry in firm level, research firm to investigate the level of R&D and innovation process to examine the sectoral perspective and explores the technological innovation in the sector climbing opportunities. This study is comprised of three main chapters. In the first chapter, the theoratical framework of sectoral innovation system is determined. The innovation patterns and technological development paths in the machinery industry are examined within the framework of sectoral innovation systems. In the second chapter, the structural analysis of the Turkish machinery industry is made. In the third chapter, there are the results of the analysis of data collected from machinery industry via standard innovation questionnaire prepared in accordance with "Oslo Guide" The proposals for policy which are considered necessary for the sector is presented in the conclusion chapter.

2. Sectoral System of Innovation

Sectoral System of innovation approach was developed in 1987 within the studies of "*Centre for Research on Innovation and Internationalization* (CESPRI)", which was founded as connected to "Università Bocconi" in Italy. Pavitt (1984) who classifies industries according to the sources of innovation has an important place in the development of sectoral system analysis. Pavitt examined about 200 important innovations which took place between 1945 and 1979 in England and classified the sectors according to the qualities and quantities of the factors that lead to the development of new technologies. Sectoral System of innovation; *can be defined as an integrated structure made up of the interactions of the actors in market and nonmarket, actors who are inclined to develop, product and market a product group and these products for a specific use."* (Malerba, 2002) A sectoral system has a structure consisting of information infrastructures, technologies, inputs and demand. The main advantage of the sectoral system of approach is; conceptual framework for a better understanding it provides of the structure and limits of the sector; of the actors and their interactions with each other; of learning, innovation and the manufacturing processes; of the sector's transformation dynamics; of factors leading to differences in performance of the companies in the sector or the internationally competitive countries in specific sectors. This conceptual framework paves the way for the development of the technology policy for certain sectors by revealing the unfavorable aspects of the approaches claiming that all sectors are similar and they can be organized and be supported with macro-policies.

Technological change is usually continuous along a technological path determined by a technological paradigm whereas the disengagements in the technological change process refer to a change in the technological paradigm (Dosi, 1982). The paradigm used here is also consistent with paradigm concept Kuhn used in the modeling of scientific development. According to Kuhn, a period of crisis interrupts the period of stabilization called as normal science period, and this period of crisis leads to the emergence of the scientific revolution, thus allowing the opening of a new period of normal science. The current scientific paradigm defines the rules, the standards and methods of scientific research shared by scientists and create a consensus atmosphere to sustain the research tradition (Kuhn, 1962). This manner of approach actually models the continuous and broken forms of development occurring in the technological development process. Solution practices of the existing technological problems are developed within this technological paradigm and specific principals shaped by the paradigm determine some problem-solving routines and lead the technological developments. After the paradigm of technological path is determined, the technological structure within the paradigm will be developed. These technological development patterns are called technological path. Technological path can also be defined as "a path which creates the realm where the innovation process is experienced" (Hayashi, 2014). It causes the developments occurring in certain industries to present specific patterns besides being dependent on the technological regime selection sphere. Especially, the models explaining in one way the innovation attributing the market a determinative role are far from explaining how these types of technological paradigm change occurred. Because, these kinds of paradigm changes occur as a result of a complex interaction established by the unresolved problems within the scientific progress, economic factors, institutional variables and existing technological path with each other (Dosi, 1982). This technological development process is considered as a change process involving the determined unpredictableness and ruptures. The underlying factors of this rupture and progression are the different effect mechanisms of innovation process. In this context, economic evolution is a multidimensional process of change which is characterized by macro innovations (radical innovations that create major technological changes) and micro innovations (small improvements concerning the existing technology) (Pol&Carroll, 2004). The contradictory and integrated structure of this process of change cause the technological changes to have continuities as well as ruptures and cause the final result of technological developments not to be foreseen as exact.

Table 1: Traditional and Emerging Characteristics of Sectoral Innovation Systems in Machinery Industry

Element	Traditional	Emerging
Form of External Linkages	➢ Bounded, Stable	➢ Open, Flexible
Geographical Scope	➢ Regional, National	➢ Regional, International
Technological Basis	➢ Mechanical	➢ Information, Intensive
Product Development	➢ Incremental	➢ Incremental, Systematic
Exchange Relationships	➢ Producers Linked With Users	➢ Partnerships of Producers, Users and Research Centers
Knowledge Base	➢ Tacit	➢ Tacit, Codified
Training	➢ Varied	➢ Varied, Internal Plus External
Corporate Form	➢ Individual, Family	➢ Individual, Corporate Groups (Limited Multinational)
Work Organization	➢ Internal Informal Collaboration	➢ Formalized and External Cooperation
Extrants	➢ Moderate Technical Barriers	➢ Higher Innovation Barriers to Entry
Demand	➢ Cyclical	➢ Cyclical
Policy	➢ National Sector Policies	➢ Regional, National, Generic European Innovation Policy

Source: Wengel & Shapira, 2004

Therefore, the information base of the sectoral system is determined by the technological development paths of the sector. Maturation of the existing technology which seems as a form of continuity will be terminated through the emergence of new technology which emerges as a rupture. When considered in this context, today, the technological development paths which are conceptualized as "Industry 3" and "Industry 4" as will shape each sector according to their own technological regimes and sectoral characteristics. "Industry 3", emerging as the

microelectronics revolution paved the way for flexible automation in the machinery industry whereas today "Industry 4", which is called the internet of things, seems to be the harbinger of smart factories period (Ege, 2014).

3. Sectoral Innovation Systems And Technological Development Paths In The Machinery Industry

Innovation in the machinery industry focuses typically on the technological properties of individual machines and their development. In general, the manufacturers are not large scaled. And many firms are concentrated in certain regions even though they export. The regional clusters of machines comprised of manufacturers, users and support organizations are observed particularly Italy and Japan and they provide scale and scope economies by enabling the sharing of tacit knowledge and thus providing a significant competitive advantage. Germany is of importance among the regional clusters. Even though well-developed organizational and technical colleges and schools are at the national level, Baden - Württenberg region, for example, holds an important cluster of machines with medium-sized enterprises. Similarly in the US, New England, Midwest and California have important clusters of machinery industry (Wengel & Shapira, 2004). Innovation system presents a regional character in which there is a high level of implicit information flow between individual companies and innovation has developed in the interactions established with customers. The structure of the industry is still based on small-sized companies; however, the global and leading companies in the sector are in co-operation with customers and research institutions and undertake cooperation activities for innovation in an increasing rate.

When the technological regime characteristics and innovation patterns of the machinery industry in the sector are considered, the industry has a typical "Specialized Supplier Industry" characteristic in which tacit knowledge accumulated in the interface between the manufacturer and the user is important for the classification of industry of Pavitt (Wengel&Shapira, 2004). The direction of innovation process in the industry is largely determined by customer requirements. New products are often developed for a specific need of the user and they are launched into the market. Therefore, the frequency of developing new product in the machinery industry is more dependent on investments. Competition conditions in the industry have monopolistic competitive market characteristics. Businesses specialize on specific product niches and prefer the path of differentiation from its competitors through product differentiation. Machinery industry manufactures the basic capital goods of many industrial sectors. Technology cooperation between firms and customers aiming to develop new products are frequently encountered in the sector. However, it is too difficult to take advantage of scale economies as the products manufactured for specific customer groups are produced less when compared to the industries producing final products. Therefore, product innovations emerge more frequently in the sector. Innovations are often the result of small cumulative changes that are continuous. Learning by using in the sector producing investment goods (learning by using) is an important source of innovation. Therefore, the industries using these machines in product development process play a role as an important source of information. The current developments in the production and the feedbacks by the customers are mostly effective in the emergence of innovation process. New products are developed more through improving certain parameters, such as the process of machinery and equipment processing and flexibility. Therefore, the radical innovations creating major changes which cause sudden ruptures in the sector are not common. As the equipments used in the production process in the machinery industry are equipments for general-purpose, they can not be transferred easily embedded in critical know-how machine and has a characteristic of tacit knowledge. Therefore, accumulation of knowledge created by the employees in the production process is increasingly becoming a more important factor. Highly skilled labor with an accumulation of knowledge in mechanical engineering with and software are critical inputs for innovation in the sector. In machinery industry, the sectoral innovation system will not only target R&D based product innovations but also it tries to conduct process and organizational innovation. As a result, the sector's goals of innovation range from the development of special machines to the development of more efficient production and service solutions.

When the technological paths of machinery industry are analyzed, it can be observed that the Industry 4 which is based on the internet of objects where the microelectronics revolution based on Industry 3 is matured is the basic technological path emerging. Microelectronics revolution revealed the important changes in the structure of manufacturing processes of engineering industries from mid-1970's on and the use of the means of production based on electronic technology began to increase in manufacturing processes (Taymaz, 1989). This transformation also called as third industrial revolution has affected the machinery industry as a technological change path. Internet has become the digital communication network of not only the individuals but also of all economic commodities after the development of technology created smart objects. This digital communication system called as "The Internet of

Things" defines the active communication of all devices, systems and services with each other and individuals via internet (Pepper & Garrity, 2014). Internet of Things will connect everyone and everything to each other on an integrated global network. People, machinery, natural resources, production lines, logistics networks, consumption habits, recycling processes and every aspect of economic and social life will be connected to the Internet of Things platform by means of software and sensors. Big Data, with all nodes - businesses, homes, vehicles - will be simultaneously fed from moment to moment in this way (Rifkin, 2015). After that, the Big Data will be processed with advanced analysis tools, transformed to smart algorithms and be transferred to the automation systems. Convergence with internet technologies causing a series of effects in the area called fourth industrial revolution or Industry 4.0. The internet of things, which is the first intelligent infrastructure revolution in history, is creating a serious splash in productivity. The Industry 4.0 concept was discovered by a working group established by the German Government. In this context, Industry 4.0 can be defined as a project in which Germany will provide the industrial structure with high technology to maintain global competitiveness in the traditional engineering industries. Everything about internet, trend involving its more use in the production and its impact on industrial processes pushed Germany and some other countries into new strategic debates and to new trends. Current trends stems from a very new technological development: linking of the real and virtual worlds of production. Increase in customer expectations in 2000's has led to the complexity of products and manufacturing processes. This situation brought multi-disciplinary studies with it and brought about the Fourth Industrial Revolution where cyber-physical systems emerging as a result of the communication between engineering products, internet network/communications and between the communications of products (Sayer & Ülker, 2014). Fourth industrial revolution focuses on the innovation of production and service including Cyber Physical Systems. In the cyber physical systems, the modern information and communication technologies such as Cloud Computing, productivity will be integrated into the systems to improve the quality and flexibility in the manufacturing sector and will provide a competitive advantage by analyzing the potential efficiency conditions (Çeliktaş, et al. 2015). The most important technological trend in machinery industry are the "Industry 4.0" applications. The sector will be shaped according to this technological paradigm as the machinery industry will produce the machines of the factories of the future. The evolution the machinery industry has experienced in microelectronics paradigm since 1990's will be accelerated by this technological path and will be moved to a new stage. After all, the traditional patterns of sectoral innovation systems have already started to change due to the fact that the use of advanced technology and software in the sector has increased. Nevertheless, the companies are trying to establish direct innovation connections into outer regions depending on the technological developments and new trends in the sector. The growing importance of encoded information, the fact that knowledge intensive technologies influence the innovation process in the sector, the trend of emergence of new inter-sectoral, inter-regional, international partners for product and process development leads to the transformation of the sectoral innovation system. This dynamic of transformation in the sector puts an increasing pressure on the traditional regional medium-sized enterprises which are dominant in the sector about their technologies of business strategy and about reshaping the networks they established with actors inner and outer regions.

4. Turkish Machinery Industry

The importance of the machinery industry in the country's manufacturing industry, which provides investment goods for all industries, is growing in the development processes of countries. Parallel to this upward trend; Total world exports in 2013 were 18.0 trillion US dollars, and the world machine tool exports totaled 2.0 trillion US dollars. The share of the machinery sector in world trade is at a level by 11.2%, as of 2013. The top five countries make about 46% of the world's exports with an amount of 816 billion US dollars. Turkey ranks 27th in this category with an export by 11 billion US Dollars for 2014. Turkey is located in the 16th position after the Netherlands with an import of machinery for 28.3 billion US dollars.

The Turkish machinery industry is a rapidly growing sector with an important export potential. According to the data of Turkish Statistical Institute, in the machinery sector about 172.000 personnel are employed in 10.787 businesses as of 2012. Beginning especially in 1970's, the machinery industry has begun to have an important place in industrial sectors, but the results of the economic crisis and the measures for transition process to Customs Union and EU integration have affected the development of the sector in a large scale. Industrial policies implemented in Turkey have a direct impact on the sector. The sector has gained a significant momentum in export realm in 2000's. Machinery exports had a 5% increase in 2014 compared to the previous year and the export sector was $ 11.1 billion. The share of the sector within total exports increased between 2005 and 2014. In 2014, import in the sector also decreased by 8% compared to the previous year and was 26.1 billion dollars. The sector's share in total imports has

fallen between 2005 and 2014 years. Even though the machinery industry has reached an important export level, it is not a decided exporter sector. The sector has a continuous foreign trade deficit. In 2013, the deficit of the foreign trade sector increased by 17.3% compared to the previous year. The foreign trade deficit for the end of 2013 is $ 17.7 billion. In 2014, the foreign trade deficit in the sector increased by 15% compared to the previous year and reached 14.9 billion dollars.

Table 2: The Share of Machinery Industry of Total Exports

Year	Total Export (Billion ABD $)	Machinery Export (Billion ABD $)	Machinery Export/Total Export (%)
2005	73,5	4,2	5,7
2006	85,5	5,1	6,0
2007	107,3	7,1	6,6
2008	132,0	8,6	6,5
2009	102,1	6,4	6,2
2010	113,9	7,5	6,6
2011	134,9	9,4	7,0
2012	152,5	9,7	6,4
2013	151,8	10,6	7,0
2014	157,6	11,1	7,1
2015*	50,4	1,8	3,5

Source: TÜİK * The first 3 Months

Table 3: The Share of Machinery Industry of Total Imports

Year	Total Import (Billion ABD $)	Machinery Import (Billion ABD $)	Machinery Import/Total Import (%)
2005	116,8	14,5	12,4
2006	139,6	16,8	12,0
2007	170,1	20,3	12,0
2008	202,0	21,0	10,4
2009	140,9	15,9	11,3
2010	185,5	19,9	10,7
2011	240,8	25,5	10,6
2012	236,5	24,8	10,5
2013	251,7	28,3	11,3
2014	242,1	26,0	10,7
2015*	70,6	6,3	8,9

Source: TÜİK * The first 3 Months

As machinery industry is an engineering-based industry, the research and development activities in industry is of importance. Turkey is not a country which provides sufficient resources for macro scale R & D. The R & D spending in the machinery sector is US $ 234.2 million in 2011, £ 301.4 million in 2012 and 335.6 million TRY in 2013. Machinery industry is among the sectors with the highest R&D spending with such a magnitude, and has about 10% share in total manufacturing industry R&D spending. Approximately 54% of the total R & D spending (7 billion TL) made by the commercial sector, 3.6 billion TL was made in direct manufacturing industry in 2013.

The realization of new products or unique product between R&D activities on selected targets is essential for the competitiveness and sustainability in the market. The original product is an indispensable demand of the industry to compete, to be able to enter the international market and to become permanent in the market. Therefore, having a certain level of R&D activities is important especially in sectors producing investment goods to have superiority over the demands from users, the market requirements and the competing products. Even though the share of machinery industry's within the total R&D spending is high, it is very difficult to say that the sector has reached a level of technological capability compatible with Industry 4.

5. A Field Research On The Level Of Technological Capabilities In Turkish Machinery Industry

5.1 Material and Method

Within the scope of the field research, the level of accumulation of technological capability in the sector was determined through the collection of data concerning the R&D and innovation processes at the firm level in Turkish machinery sector. According to the Oslo Guide determining international standards in innovation measures, there are two basic approaches in the collection of datas on innovation activities, these are "(Subject Focus)" and "(Object Focus)" (OECD 2005). Subject focus starts from the innovative behaviors and activities of the company as a whole. The purpose of this approach is to determine the factors that influence the innovation at firm level, the incentives and the barriers against innovation through the help of a questionnaire sent to the company. Within the scope of this study, "Subject Focus" was adopted in the process of data collection. The data were collected through "Innovation Survey" which was prepared in accordance with Oslo Guide for this purpose. This study is fundamentally based on the implementation of the questionnaire and evaluation of results. Each question in the questionnaire intended to collect the necessary data to measure the impact of the related item in the model. Companies that make up the study sample were selected by the utilization of this database. There are 250 firms in the selected sample within the scope of this study. Simple random sampling method was used in the creation of the sample. The pilot implementation of the research was made in order to give a final shape to the questionnaire. After the pilot study, it was observed that the questionnaire has the capability to measure the subject of the survey. By using the data obtained from the results of the pilot study a reliability analysis was conducted for Likert-type questions in the survey. Cronbach's alpha value, the reliability factor of the questionnaire was found to be 0.80. The fact that Cronbach's alpha value being over 0.70 is means that the scales used is reliable according to the relevant literature (Bayram, 2012) Therefore, the survey questionnaire was considered to have the reliability. As the questionnaire was found "reliable" and "valid", field research process of the survey was started.

5.2. Results

The findings concerning the field research based on the data collected from the machinery industry is presented and analyzed using descriptive statistics and. Within the scope of this study, data was collected from the businesses in sub-sectors in the Turkish machinery industry The distribution of the survey sample in terms of sub-sectors are presented in Table 4.

Table 4: Subject of Firms' Activity

Subject of Activity	***N***	***%***
Other Specific Purpose Machines (Rubber, Plastics etc. Processing Machines)	52	20.8
Other General Purpose Accessories Parts	26	10.4
Textile, Ready-Made Garment and Leather Processing Machines	23	9.2
Manufacture of Motors and Turbines	20	8.0
Machine Tools	18	7.2
Construction and Mining Machines	15	6.0
Food, Beverage etc. Processing Machinery and Equipment	15	6.0
Manufacture of other agricultural and Forestry Machinery	14	5.6
Pump and Compressor Manufacturing	13	5.2
Industrial Furnace, Oven, Burner	12	4.8
Loading, Lifting and Transportation	10	4.0
Paper, Cardboard etc. Machines	5	2.0
Manufacture of Faucets and Valves	4	1.6
Manufacture of Bearings, Gears, Gear Set and Headstock	4	1.6
Metallurgy Machines	4	1.6
Total	***250***	***100.0***

When we look at the number of employees in the businesses participating in our survey, we can see that 15.6% of them are micro businesses with 1-9 employees, 59,2 % of them are small firms with 10-50 employees, 20.8% of them are medium-sized firms with 51-250 employees, and approximately 4% of them are large firms with more than 250 employees. We can see that the majority of the businesses giving responses for the questionnaire are

SMEs on the basis of the number of employees. The most distinct feature of Turkey's manufacturing industry, is that the percentage of businesses in the SME scale is much higher. As in the examples of other countries, the structure of the industry comprised of enterprises in the SME scale is more evident in machinery industry in particular. According to data obtained in the study, 35.2% of the businesses in the scope of the survey data is regional, 30.8% of them is national, and 34% stated that their main area of activity is the international markets. Thus, it is seen that the majority of businesses serving to national and international markets. When the findings related to whether the firms make export or not, we can see that 76.4% of them make export. This shows us that the machinery industry, one of the locomotive sectors of the manufacturing industry is a very outward sector. According to the answers of the firms answering our questionnaire to the questions whether they conducted any R&D activity in 2014, 50.4% of these firms stated that they conducted R&D activities, while 49.6% stated that they did not have such an activity.

When we examined the reasons underlying in the firms' R&D activities, 37.3% of them point the factor of increasing the quality of the product, 24.6% of them point the factor of increasing product variety, 13.5% of them point to increasing the market share, 7.9% of them point to the factor of creating new market, 5.5% of them point to the customer demand, 3.2% of them point to the factor of learning about new technologies as the most important reason for the R&D activities. Especially, the first five factors are found to have significant influences on their R&D activities by more than 80% of the firms. It is observed that the firms aim to increase quality, to gain advantages over its competitors by increasing their market share and increase their learning ability by learning new technologies when they undertake R & D activities.

When the importance level of the internal factors hindering R&D activities is examined according to the firms which participated in the survey and which did not conduct any R&D activity in the last three years, it is seen that the most important internal factor is the lack of financial resources. The lack of financial resources for R&D activities is the most important factor for 35.6% of the firms. 8.5% of the firms point to the factor of managers' not needing R&D, 12.1% of them point to the lack of R&D personnel, 8.9% of them point to the factor of the lack of R&D infrastructure in firms, and 8.1% of them point to the lack of a specific R&D strategy in firms as the most important internal barrier for R&D activities. The fact that the firms see the lack of financial resources as the most important obstacle shows us that limitation in the financial resources for R&D is an essential blocking factor.

Table 5: Internal Factors Preventing the Firms from Conducting R&D Activities

Internal Factors Preventing the Firms from Conducting R & D Activities	***N***	***%***
Lack of Financial Resources	45	35.6
Manager's Not Needing R & D	23	18.5
Companies' Lacking R&D Staff	15	12.1
Companies' Lacking R&D Infrastructure	11	8.9
Companies' Lacking a Corporative R&D Strategy	10	8.1
None Obstacle	7	5.6
Financial Conditions	3	2.4
Lack of Time	2	1.6
Lacking the Necessary Knowledge for R&D Opportunities	1	0.8
None	1	0.8
I have no opinion	4	3.2
Other	2	1.6
Total	***124***	***100***

When the innovation activities other than R&D companies are analyzed, the data obtained can be summarized as follows. According to this, 76.8% of the firms engaged in the activity of machinery, hardware and software purchases for development of product and process innovation, 32.4% of them engaged in technology transfer for the development of product and process innovation such as getting patent or license, 40.4% of them engaged in such activities as industrial design, engineering, market research and marketing research, and another 40.4% engaged in such activities as educational services such for the development of product and process innovation. Machinery and equipment investments for the remaining firms are one of the basic technological selection activities and are one of the firms' main sources of technological change. It is also observed that the firms in Turkish machinery sector attach importance on investment in machinery and equipment. The technology transfers based on the purchase of intellectual property rights are the other innovation activities of firms that were least preferred.

Table 6: Other Innovation Activities

	Yes		No	
	N	*%*	*N*	*%*
Purchase of Machine, Hardware and Software for the Development of Product and Process Innovation	192	76.8	58	23.2
Technology Transfer for the Development of Product and Process Innovation such as Getting Patent or License	81	32.4	169	67.6
Activities such as Industrial Design, Engineering, Market Research, Marketing Research	101	40.4	149	59.6
Purchase of Educational Services for the Development of Product and Process Innovation	101	40.4	149	59.6

According to the findings obtained in research, among the firms participating in the survey, the rate of the firms that have made product innovation in the last three years is 48%. The companies that participated in the survey stated that 79.2% of the product innovations was new to the market, that 78.5% of product innovations was new to the country and that 93.2% of product innovations was new to the company. The rate of the surveyed firms which conducted any process innovation in the last five years is 25.6%.

The results of the cross-table analysis concerning the relationship between product innovation and process innovation obtained through the data obtained in the survey are presented in Table 7. According to these results, 88.9% of firms engaged in the process are also engaged in product innovation at the same time, whereas only 38.6% of the firms engaged in product innovation are engaged process innovation. In light of these findings, the businesses which can develop process technology can usually develop new products, too, but it is not vice versa. That is to say, the rate of those conducting the process innovation is lower among the businesses conducting product innovation. This situation is consistent with the phenomenon that the share of product innovation in the innovation processes of machinery industry is high. We can suggest that the most important elements of the businesses in having a competitive superiority is that the firm manufactures quality products which will meet customer demands and expectations better than the competitors, that the firm has the height of the innovative capacity, an organizational structure which is flexible and open to change and that it has successful strategy development processes. It is an expected result that the rate of the firms stating that they made production innovation is higher than the rate of firms stating that they made process innovation for machinery industry which has a *Specialized Supplier Industry* structure. So the companies in the sector focus on product development through the gradual innovations in line with demands from clients.

Table 7: Process Innovation and Product Innovation Cross Table Analysis

	Did Your Company make any Process Innovation in Turkey?		***Total***
Did Your Company make any product innovation in Turkey?	Yes	No	
Yes	56 %38,6 %88,9	89 %61,4 %47,8	145 %100,0 %58,0
No	8 %7,6 %11,1	97 %92,4 %52,2	105 %100,0 %41,6

Total	64 %25,6 %100,0	186 %74,4 %100,0	250 %100,0 %100,0

(Pearson Chi-Square: 282,719, Cramer's V: ,752, p= ,000)

The findings related to the collaboration level between university and industry is also included. 97.6% of the firms participating in the survey stated that they did not cooperate with any university. The distributions of types of cooperation made by the firms stating that they were in cooperation with the university are presented in Table 8. According to these findings, 34.8% of the firms made research and development studies for technology development, 21.7% of them received consultancy services from the university, and 10.1% received educational services. 10.1% of the firms provide support for internships to university students. 10.1% of the firms collaborated with universities in determining the topics of master and doctoral theses in accordance with the requirements of the industry. Making use of the university facilities for such engineering industries as machinery industry at such low levels presents a major problem. Universities do not only educate the workforce that is important for the sector but they also make the transfer of technology to the firms possible through the research activities they do. The rate of the firms that benefit from the services offered by the University Technology Transfer Office is about 4.3%. When the results obtained from this study is evaluated, we can say that relationships the firms established with universities is in the field of research and development, but it is insufficient considering the whole firms. Cooperation activities such as getting educational, advisory services and benefiting from technology transfer office services are considered to be so inadequate. For the sector to become a globally competitive sector, the increase in the cooperation areas that the sector will establish with universities is inevitable.

Table 8: University-Industry Cooperation of Firms

(The Firms Have Been Presented More Than One Choice)

University-Industry Cooperation of Firms	***N***	***%***
Activities of R&D and Innovation	24	34.8
Activities of Counselling	15	21.7
Educational Activities	7	10.1
Providing Internship Support	7	10.1
Supporting the University in the Determination of Thesis Subjects	7	10.1
Making Use of the Technology Transfer Office	3	4.3
Participating in Classes at the University as an Applied Trainer	1	1.7
Providing Support for Data	5	7.2
Total	***69***	***100***

Conclusions regarding the level of utilization of support services provided to the firms participating in the survey are as follows; 28.4% of the firms made use of the support services provided by TUBITAK, 3.2% made use of services by the Technology Development Foundation, 6.4% made use of services by TUBITAK Marmara Research Center and 51.6% made use of services by KOSGEB (Small And Medium Industry Development Organization).

The fact that a significant part of the businesses is in SME scale increased the rate of the utilization of support services provided by KOSGEB. It is observed that the rate of the firms benefiting from TEYDEP TUBITAK projects is low. This situation points out that a major part of the firms are insufficient in terms of the level of manpower that will prepare R&D projects and of the technological capabilities. It is observed that the rate of the firms benefiting from the project supports given especially by TUBITAK-MAM and TTGV to develop technologies is low. In particular, the firms do not make use of the R&D project supports which will contribute to the enhancement of the level of technological capabilities in the sector commensurately. This may be a result of the fact that the firms can not set financial resources aside due to financial constraints. Another important factor may be the lack of engineers who have the experience and capability to prepare and to continue R&D projects. Both factors constitute a significant constraint on increasing the level of technological capabilities for the companies in the sector.

Conclusion

Therefore, the machinery industry is a sector which has a key importance for the development of national industry. Due to its key importance, it is a sector which should be strategically supported and whose issues should be dealt with. The biggest difference of machinery and equipment manufacturing sector from other sectors is the

obligation of making project, R&D and engineering designs at every stage. Machines, machine parts and equipments are often passed onto the design and project phase according to customer needs and requests and then they are re-planned and produced. Machinery industry has a complex structure which is not suitable for mass production, but labor-intensive and expanding on a wide area with its sub-sectors. Machinery industry is a main sector which provides inputs such as investment and intermediate goods to all sectors of manufacturing industry and which provides technological progresses in the development of the industry. When the machinery industry is examined on a global scale, it is seen that the sector is today on the verge of an important technological paradigm change. The periods when the techno-economic paradigms change open "windows of opportunity" into development direction for especially the lagging countries that can adapt to this change process. The effect of software and microelectronics in machinery sector increased in the 1980s, and especially Japan and, to some extent South Korea made use of windows of opportunity opened by this transformation, and they took place among such countries as USA, Germany and Italy which are influential in the machinery industry in the present time. Today, the Industry 4 paradigm coming to the fore with the "Internet of Things" offers a technological path which will have significant effects on the whole branches of manufacturing industry including the sector. This new paradigm opens important windows of opportunity for the sector. Machinery sector will produce the machines of smart factories based on full-automation. Of course, the reason for the machinery industries of the developing countries not to be able to benefit from this window of opportunity well enough is that the sector is insufficient in technology, and the sector also needs a support in terms of strategy.

As a result of this study, when the level of technological capabilities of the firms in the machinery industry was evaluated as a whole, the following key findings were reached.

- It is seen that the ability of the firms in the machinery industry to conduct product innovation is more advanced than the ability to make the process innovation.
- Although the rate of innovative companies in the machinery industry is high compared to Turkey's average, relationships of the innovative companies in these sectors with such actors as other companies, research institutions and universities are very weak. It is seen that the more than half of businesses does not conduct state-funded R & D projects.
- When the number of employees is taken into consideration, it is seen that these businesses are small-scale enterprises rather than corporate structures. As in all over the world, the majority of machine manufacturers is SME's in Turkey. Therefore, firms can not benefit from the advantages of scale-economy.

Even if Turkish machinery industry has a certain technological capability accumulation, this capabilities distributed unequally in the sector. Although there are leading innovative and competitive firms, there are a large number of small and micro-sized firms having low technological capability accumulation as well. It is observed that the sector's capability of monitoring the newly emerging technological paths in the machinery industry is extremely weak. The sector's innovation system characteristics are considered to be more traditional in nature as described in Table 1. For Turkey, which always lagged behind in the previous industrial revolutions, to be able keep up with the new industrial revolution is of critical importance. Turkey should begin to make the use of existing industrial advantages better and to improve this step by step.

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