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A model proposal oriented to measure technological innovation capabilities of business firms – a research on automotive industry

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Abstract

In the scope of this work; a model proposal and an innovation scale oriented to measure technological innovation capabilities of business firms in manufacturing industry sector had been formed. Studies on theoretical framework and meetings of consultative committee of experts guided the formation of the scale. With the scale prepared, a research project designed on automotive industry in Turkey by measuring technological innovation capabilities of primary industrial manufacturers in this sector. The results of this research bring on the necessity of further studies about the low level of technological innovation capabilities in automotive industry.

Keywords: Innovation, Technological Innovation, Technological Innovation Capability, Innovation Scale, Automotive Industry

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1. Introduction

Attributed to Galileo Galilei, the famous quote; "*Count what is countable, measure what is measurable. What is not measurable, make measurable*" is fundamental to modern management. In management terms, it translates as: "*You cannot manage what you cannot measure or do not measure*" [1]. In 1883, Scottish physicist, William Thomson (often referred as Lord Kelvin) expressed his idea in a lecture; "*I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be*" [2].

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In accordance with these expressions and ideas above, we can come to a conclusion that we cannot manage technological innovation capability if we cannot measure or do not measure it. On the other hand, the complexities of innovational systems make them difficult to measure and thus increase the importance of the measurement system that will be used.

2. Literature Review

2.1. Innovation

Innovation, perceived as a relatively new concept in management literature. Contrary to popular belief, innovation is not a new phenomenon. Arguably, it is as old as humankind itself. There seems to be something inherently "human" about the tendency to think about new and better ways of doing things and to try them out in practice [3]. In the history of social sciences, many scientists with various different perspectives had worked on this very old and well-established concept.

When we examine the etymology of the word "innovation"; we would discover the word "innovatus" as derived from Latin; in + novus meaning "make changes in something established" [4]. The root word; nova, (singular adjective of novus) means "new" and used to describe "a new star not previously known" in Latin. But those etymologic explanations are insufficient to explain and understand the meaning of innovation.

According to Schumpeter, "*To produce means to combine materials and forces within our reach. To produce other things, or the same things by a different method, means to combine these materials and forces differently*" [5]. He used the concept "new combinations" for this explanation. We can clearly see a strong relation between the meaning of innovation that we use today and Schumpeter's "*new combinations*". According to him, these "new combinations" can be; a new good that is one with which consumers are not yet familiar; a new method of production, that is one not yet tested by experience in the branch of manufacture concerned; a new market; a new source of supply of raw materials or half-manufactured goods; or a new organization of any industry. As can be seen clearly, innovation cannot be related only with "new goods".

Another perspective to innovation concept comes from Rogers and Shoemaker; innovation is an idea, practice or object perceived as new by an individual. It matters little, whether or not an idea is "objectively" new [6].

The Organization for Economic Co-Operation and Development's (OECD) document "The Measurement of Scientific and Technological Activities, Proposed Guidelines for Collecting and Interpreting Technological Innovation Data" (also known as the Oslo Manual), contains this definition of innovation; "*An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations*" [7].

In brief, innovation is a blend of strategic planning, research and development, marketing, project management, team work, training and creative thinking [8].

2.2. Relations between innovation and similar concepts

Many people confuse the terms innovation and invention. Indeed, if we ask people for an explanation we would collect a diverse range of definitions, because these terms are often used interchangeably. We

can distinguish innovation from invention by suggesting that innovation is concerned with the commercial and practical application of ideas or inventions. Invention, then, is the conception of the idea, whereas innovation is the subsequent translation of the invention into the economy. The following equation helps to show the relationship between the two terms. "*Innovation = theoretical conception + technical invention + commercial exploitation*" [9].

Economically, inventing something is differentiate from the activity of innovation. The applicability and practicability of the invention or the creation is very important in order to talk about an innovation [10]. Noori, combines the concepts innovation, technology, invention and creativity as seen below [11].

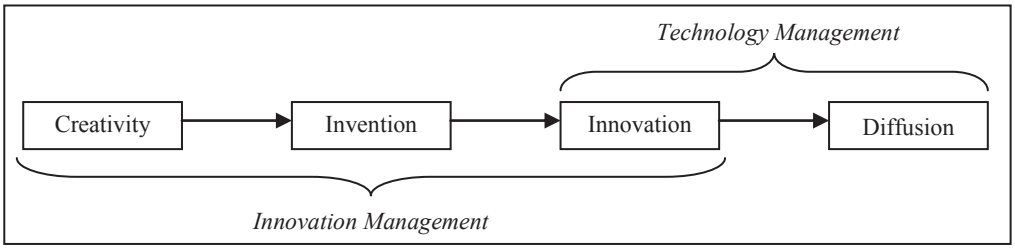

Figure 1. Relations between Creativity, Invention, Innovation and Technology

2.3. Technological innovation

Technological innovation is a sum of product (include services) and process innovations described above. The development of a new product or process, as well as major technological changes in existing products and processes must be considered in this context.

2.4. Technological innovation capability

Technological innovation capability (TIC) is a special asset of an enterprise, which comprises different key areas, such as technology, production, process, knowledge, experiences and organization [12]. Many authors highlight the different characteristics of mainstream and newstream processes [13]. Kanter argued that organizations are most effective where the different resource needs of the "mainstream" and "newstream" are recognized and their management largely autonomous. Managing business units in this way assists organizations in balancing the tensions of stability and change. An innovation capability is therefore defined as the ability to continuously transform knowledge and ideas into new products, processes and systems for the benefit of the firm and its stakeholders. Innovation capability is not just an ability to be successful at running a business newstream, or to manage mainstream capabilities. Innovation capability is about synthesizing these two operating paradigms [14].

3. Measuring Technological Innovation Capability

Measuring innovativeness is difficult to do well with a single measure because innovation can be achieved in many ways [15]. In the past, innovation measurement tended to be confined to R&D. This is frequently considered unsatisfactory since the innovation process also requires a number of non-R&D activities such as the acquisition of patents and licenses, design, training of personnel, market research and investment in new production capacity. While such non-R&D expenditure may be of considerable quantitative importance, innovation policy as well as theorizing and modeling still have to rely on R&D statistics as the major source of information systematically collected over time and across all OECD countries. In many of these countries, information about non-R&D expenditure on innovation is virtually nonexistent [16].

The European Innovation Scoreboard (EIS) is the instrument developed at the initiative of the European Commission, under the Lisbon Strategy, to provide a comparative assessment of the innovation performance of EU Member States. The EIS 2007 includes innovation indicators and trend analyses for the EU27 Member States as well as for Croatia, Turkey, Iceland, Norway, Switzerland, Japan, the US, Australia, Canada and Israel [17].Theinnovation indicators in EIS 2007 are assigned to five dimensions and shown in the table below.

Table 1. EIS 2007 Indicators

1.INNOVATION DRIVERS (INPUT DIMENSION)
1.1 S&E graduates per 1000 population aged 20-29
1.2 Population with tertiary education per 100 population aged 25-64
1.3 Broadband penetration rate (number of broadband lines per 100 population)
1.4 Participation in life-long learning per 100 population aged 25-64
1.5 Youth education attainment level (% of population aged 20-24 having completed at least upper secondary education)
2.KNOWLEDGE CREATION (INPUT DIMENSION)
2.1 Public R&D expenditures (% of GDP)
2.2 Business R&D expenditures (% of GDP)
2.3 Share of medium-high-tech and high-tech R&D (% of manufacturing R&D expenditures)
2.4 Share of enterprises receiving public funding for innovation
3.INNOVATION & ENTREPRENEURSHIP (INPUT DIMENSION)
3.1 SMEs innovating in-house (% of all SMEs)
3.2 Innovative SMEs co-operating with others (% of all SMEs)
3.3 Innovation expenditures (% of total turnover)
3.4 Early-stage venture capital (% of GDP)
3.5 ICT expenditures (% of GDP)
3.6 SMEs using organizational innovation (% of all SMEs)
4.APPLICATIONS (OUTPUT DIMENSION)
4.1 Employment in high-tech services (% of total workforce)
4.2 Exports of high technology products as a share of total exports
4.3 Sales of new-to-market products (% of total turnover)
4.4 Sales of new-to-firm products (% of total turnover)
4.5 Employment in medium-high and high-tech manufacturing (% of total workforce)
5.INTELLECTUAL PROPERTY (OUTPUT DIMENSION)
5.1 EPO patents per million population
5.2 USPTO patents per million population
5.3 Triad patents per million population
5.4 New community trademarks per million population
5.5 New community designs per million population

Macro indicators (state level) of EIS shown in the table above, converted into micro indicators (business level) in this study. A consultative committee of experts had been constituted to guide this conversation process. The members of this committee were specialists from Turkish automotive sector and national academic institutions.

After studies on theoretical framework and meetings with consultative committee of experts, three factor groups; “input factors”, “process factors” and “output factors” determined for the measurement of technological innovation capabilities of business firms. Thereby the factors that overlooked by the traditional output-oriented measurement techniques would also taken into account. The factor groups, main factors in each factor group and number of sub-factors (determined to measure the main-factors) in each main factors and the percentages of each factor group decided by using factor scoring method can be seen in the Table 2 below.

Table 2. The factor groups, main factors in each factor group and number of sub-factors

Factor Groups	Points	Percent	Main Factors	Number of Sub-Factors	Points	Percent
Input Factors	360	36	Human Resource	10	75	7,5
			Knowledge Creation	4	120	12
			Vision and Strategy	8	55	5,5
			Entrepreneurship	8	110	11
Process Factors	230	23	Innovative Organization Culture	6	60	6
			Control	13	125	12,5
			Other process factors	3	45	4,5
Output Factors	410	41	Tangible Returns	6	160	16
			Intellectual Capital	8	250	25
	1000	%	*Total*	66	1000	%

Subsequent to preparing factor groups that measure technological innovation capabilities of organizations and also the main factors, the sub-factors deemed to be present within each single main factor have been determined. These sub-factors are as shown in Table 3 below. There are 66 sub-factors determined to measure the technological innovation capability of a business firm.

To ensure that these sub-factors can provide comparable results with the data gathered from organizations, utmost care has been paid to deal with numeric, objective and proportional factors which are at the same time the variables themselves.

Table 3. The Variables Prepared to Measure Technological Innovation Capabilities

			Degrees and Points					
Factor Groups	**Main Factors**	**Sub-Factors**	**WS***	**I**	**II**	**III**	**IV**	**V**
Input Factors	Human Resource	On the basis of total number of employees, number of higher education graduates below the age of 30 per 10 employees	5	1	2	3	4	5
		On the basis of total number of employees, number of engineering faculty graduates per 10 employees	5	1	2	3	4	5
		On the basis of total number of employees, number of Research&Development personnel per 10 employees	10	2	4	6	8	10
		Per person annual training duration of organization's directors	5	1	2	3	4	5
		Per person annual training duration of organization's white-collar employees	5	1	2	3	4	5
		Per person annual training duration of organization's blue-collar employees	5	1	2	3	4	5
		The ratio of per person annual training duration of organization's directors in themes such as innovation, creative thinking etc. to the length of total training	10	2	4	6	8	10
		The ratio of per person annual training duration of organization's white-collar employees in themes such as innovation, creative thinking etc. to the length of total training	10	2	4	6	8	10
		The ration of per person annual training duration of organization's blue-collar employees in themes such as innovation, creative thinking etc. to the length of total training	10	2	4	6	8	10
		The number of total personnel (%) that are deemed to be creative or potentially creative by directors	10	2	4	6	8	10
	Knowledg e Creation	The ratio of direct R&Dspending of the organizations in the last one year (With respect to total revenue of the last one year %)	60	12	24	36	48	60
		The ratio of employee training (education and development) spending of the organizations in the last one year (With respect to total revenue of the last one year %)	30	5	10	15	20	30

		The quality of organizational innovation-creation centered promotion and awarding system (if there is any)	10	0	2,5	5	7,5	10
		The extent of practicing organizational innovation-creation centered promotion and awarding system's outputs and the extent these practices turn into innovation	20	0	5	10	15	20
	Vision and Strategy	Whether the organization possesses a definite vision statement	5	0				5
		Whether the organization possesses an innovation strategy	10	0				10
		The extent of familiarity of such innovation strategy by directors	5	1	2	3	4	5
		The extent of familiarity of such innovation strategy by employees	5	1	2	3	4	5
		The extent of full understanding of such innovation strategy by directors	5	1	2	3	4	5
		The extent of full understanding of such innovation strategy by employees	5	1	2	3	4	5
		The extent of practicing such innovation strategy by directors	10	2	4	6	8	10
		The extent of practicing such innovation strategy by employees	10	2	4	6	8	10
	Entrepreneurship	The ratio of last one year's innovation spendings (excluding R&D) (With respect to total revenue of the last one year %)	40	8	16	24	32	40
		The extent of practicing the innovation types (Goods, Services, Process, Organizational, Business Model)	10	2	4	6	8	10
		The level of the density of innovation-oriented cooperations	10	2	4	6	8	10
		The contribution of the cooperation with an external partner on the basis of new idea creation in innovation projects over the process of innovation creation	10	2	4	6	8	10
		The contribution of the cooperation with an external partner on the basis of product (good and/or service) development in innovation projects over the process of innovation creation	10	2	4	6	8	10
		The contribution of the cooperation with an external partner on the basis of process development over the process of innovation creation	10	2	4	6	8	10
		The contribution of the cooperation with an external partner over the process of developing all functions of the organization	10	2	4	6	8	10
		The quality of the financial or similar support received by the organization for innovation projects from various support foundations in the last four years	10	2	4	6	8	10
Process Factors	Innovative OrganizationCulture	The level of enthusiasm and willingness for innovation of the top management in the organization	15	3	6	9	12	15
		The level of enthusiasm and willingness for innovation of the middle and lower management in the organization	15	3	6	9	12	15
		The level of enthusiasm and willingness for innovation of the organization's white-collar employees	15	3	6	9	12	15
		The level of enthusiasm and willingness for innovation of the organization's blue-collar employees	5	1	2	3	4	5
		The level of promoting innovation creation processes, innovative business culture amongst sub-industry / supply industry companies that provide semi-finished products	5	1	2	3	4	5
		The level of promoting innovation creation processes, innovative business culture amongst companies that provide services such as security, cleaning, food	5	1	2	3	4	5
	Control	The percentage (if there is any) of completing the innovation projects within the specified duration by the organization during the last four years	15	3	6	9	12	15
		The percentage (if there is any) of completing the innovation projects within the specified budget by the organization during the last four years	15	3	6	9	12	15
		The percentage (if there is any) of completing the innovation projects within the specified quality standards by the organization during the last four years	15	3	6	9	12	15
		The frequency of receiving feedback on implemented innovation creation projects from the suppliers	5	1	2	3	4	5
		The frequency of receiving feedback on implemented innovation creation projects from the customers	5	1	2	3	4	5
		The frequency of receiving feedback on implemented innovation creation projects from research institutes and universities	5	1	2	3	4	5
		The frequency of receiving feedback on implemented innovation	5	1	2	3	4	5

		creation projects from specialist establishments on intellectual property rights						
		The level that society appreciates innovation capacity of the organization	10	2	4	6	8	10
		The level that customers appreciate innovation capacity of the organization	10	2	4	6	8	10
		The level that suppliers appreciate innovation capacity of the organization	10	2	4	6	8	10
		The level that competitors appreciate innovation capacity of the organization	10	2	4	6	8	10
		The level that partners appreciate innovation capacity of the organization	10	2	4	6	8	10
		The level that organizational management itself appreciates innovation capacity of the organization	10	2	4	6	8	10
	Other process factors	The level that organization's "being innovative" factor is present in the processes that are within the scope of human resources management technique (work analysis, performance evaluation, pricing etc.)	20	0	5	10	15	20
		The frequency that organization takes part in national fairs which provide opportunity of promoting the new products (goods/services) in the market	10	2	4	6	8	10
		The frequency that organization takes part in international fairs which provide opportunity of promoting the new products (goods/services) in the market	15	3	6	9	12	15
Output Factors	Tangible Returns	With respect to total employee cost, the ratio of the decrease in labour force cost that occurs with the implementation of process innovation projects in organizations	20	4	8	12	16	20
		With respect to total production cost, the ratio of the decrease in operational costs that occur with the implementation of process innovation projects in organizations	20	4	8	12	16	20
		The break-even point duration of the organization's product (goods/services) groups from the stage of idea (project development) to the stage of retrieving the product (goods/services) from the market	10	2	4	6	8	10
		The revenue that the organization has received during the last four years from the sale of new products (goods/services) below age three	30	6	12	18	24	30
		The ratio of the revenue that the organization has received during the last four years from the sale of new products (goods/services) below age three to the total revenue received from the sales during the same period	40	8	16	24	32	40
		The ratio of the revenue that the organization has received during the last four years from the sale of new products (goods/services) below age three to the total spending on innovation creation activities during the same period	40	8	16	24	32	40
	Intellectual Capital	The number of certificates (%) received by the organization upon application for patent/useful model during the last four years	20	0	5	10	15	20
		The ratio of the certificates (%) received by the organization upon application for patent/useful model during the last four years to the number of Research&Development personnel	40	0	10	20	30	40
		The ratio of the international (EPO, Triad) patent/useful model certificates received by the organization during the last four years to the number of average annual Research&Development personnel	40	0	10	20	30	40
		The ratio of the industrial design certificate applications that were awarded with certificates during the last four years	40	0	10	20	30	40
		The ratio of the number of national industrial design certificates received by the organization during the last four years to the number of average annual Research&Development personnel	40	0	10	20	30	40
		The ratio of the number of international (EPO, Triad) industrial design certificates received by the organization during the last four years to the number of average annual Research&Development personnel	40	0	10	20	30	40
		Whether the organization has received any national innovation awards	10	0				10
		Whether the organization has received any international innovation awards	20	0				20
		Total	1000					1000

* WS: Weighing Scores

The functioning of the technological innovation capability measurement model that is put forth in current study is as explained in Figure 2.

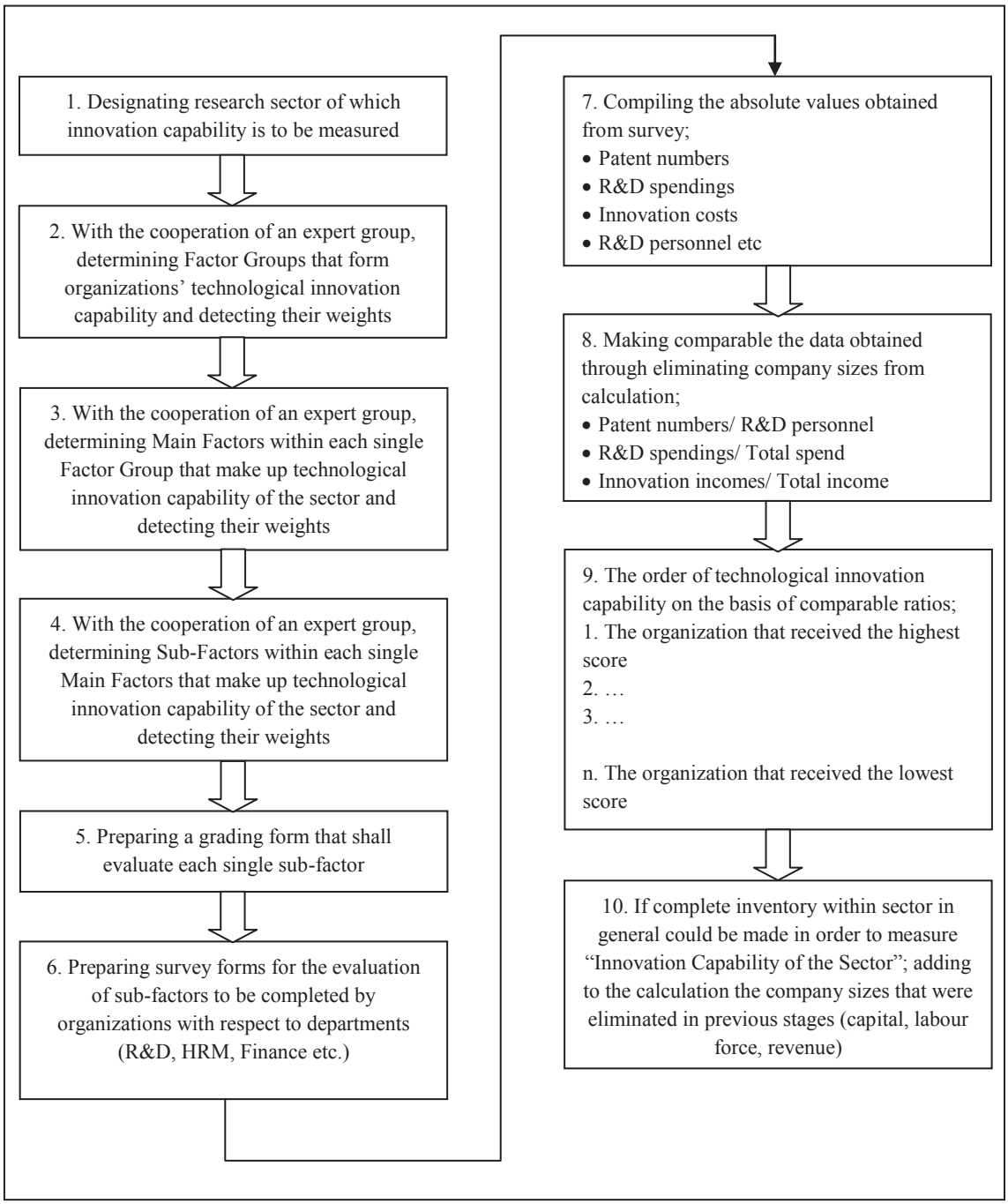

Figure 2. Functioning of Technological Innovation Capability Measurement Model

As stated in the explanation of the model above as well, subsequent to calculating factor score scale measuring technological innovation capabilities and comparable capability scores, if complete inventory within sector in general could be made, then the technological innovation capability score of the sector can be calculated.

The technological innovation capability score of the sector can be calculated as below; (In calculating technological innovation capability score of the sector with respect to paid amount of capital, total number of employees and total annual revenue the variables below stated shall be utilized).

Organization's score of innovativeness; I
Weighted organization innovativeness score; I'
Total innovativeness score of research sampling; SI
Total innovativeness score of the sector; TI
Organization's paid amount of capital; C

Research sampling's total paid amount of capital; $SC = \left(\sum_{1}^{n} C \right)$

Organization's total number of employees; E

Research sampling's total number of employees; $SE = \left(\sum_{1}^{n} E \right)$

Organization's total annual revenue; R

Research sampling's total annual revenue; $SR = \left(\sum_{1}^{n} R \right)$

$$I' = \frac{I \times C \times E \times R}{\left(\sum_{1}^{n} C \right) \times \left(\sum_{1}^{n} E \right) \times \left(\sum_{1}^{n} R \right)} \rightarrow \qquad SI = \sum_{1}^{n} I'$$

If the complete inventory of the research sector in general could be made; SI = TI is the result. In case complete inventory could not be made it is obvious that SI score to be obtained shall give an idea only to the extent that the scale represents overall sector.

4. Research

4.1. Research objectives, methodology, scope and constraints

The purpose of this study is implementing the model that has been developed to measure organizations' technological innovation capabilitieson automotive key industry organizations in Turkeyand then compile the obtained findings. Type of research is quantitative research. Data is gained with two approaches as distributing surveys in hand and in-depth interviews. Surveys and interviews are implemented in term of July-September 2008. Thus, the data collected is cross-sectional. Participation to research is relying on essence of voluntary. Turkish automotive industry was chosen as the scope of this research.

Since one single survey form would be filled with too many questions, three surveys addressing to three separate departments of each organization have been prepared (See Table 4).

Table 4. The Prepared Survey Types and Extensive Information on Surveys

	Survey Type	1st survey prepared for Human Resources Management departments of organizations	2nd survey prepared for Research and Development departments of organizations	3rd survey prepared for Administrative and Finance departments of organizations
Survey sub-sections	Cover and cover letter	Total two pages, except the title of the addressed department manager in cover letter, the text is literally the same with the rest of the surveys	Total two pages, except the title of the addressed department manager in cover letter, the text is literally the same with the rest of the surveys	Total two pages, except the title of the addressed department manager in cover letter, the text is literally the same with the rest of the surveys
	Descriptive information	**8** open and close ended questions	**5** open and close ended questions	**15** open and close ended questions
	The sections covering the information on model implementation	**11** open and close ended questions	**23** open and close ended questions	**5** open and close ended questions
	Total number of questions	**19** questions	**28** questions	**20** questions

One of the basic constraints of the research is the difficulty of the measurement of technological innovation capability because of the complex structure of innovations. A second constraint is the unwillingness of business managers to share all the information required by the survey and consequently low rate of return.

4.2. Research universe and sampling

The universe of present research consists of registered members of Automotive Manufacturers Association of Turkey (as of July 2008). Upon the termination of *Otoyol*, the number of organizations in universe was reduced to seventeen. Through judgment sampling method from this universe, organizations that can represent different sub-groups with respect to both capital size and capital ownership were selected and included within sampling which is manifested in Table 5.In addition to seven organizations that are included in sampling *Bosch Bursa Diesel* company that manufactures diesel equipment which is the most substantial by-industry product of automotive industry has also been included in sampling.Pilot study of the research has been conducted in *Mercedes-Benz Turk* company which was the first business firm visited within the scope of sampling. Subsequent to the pilot study conducted in this organization, certain changes and improvements have been made in survey forms.

It has been considered that there would be decrease in received feedbacks if specific surveys for Human Resources, Research&Development and Administrative/Finance departments of each eight organization were to be sent via fax, e-mail or post; hence face-to-face interviews have been deemed to be more favorable and applicable.In the initial attempts to conduct face-to-face interviews, *Anadolu Isuzu* company turned down the invitation call made to explain objective of the research and present the survey forms. *Tofaş, BMC, Ford Otosan, Oyak Renault, Mercedes Benz Turk, Honda Turkey* and *Bosch Diesel* companies accepted the call. Upon the meetings, *Oyak Renault* company –based on the company's pretaken organizational decisions- rejected participating in the research. The interviews conducted with *Tofaş, BMC, Ford Otosan, Mercedes Benz Turk, Honda Turkey* and *Bosch Diesel* have ended satisfactorily, organizational data-gathering process via survey has been initiated.Having failed to provide feedback in the preset data gathering stage of research, *Ford Otosan* and *Honda Turkey* companies have been excluded of the research; data gathering stage of the research has been completed with the data received from *Tofaş, BMC, Mercedes Benz Turk And Bosch Diesel* companies. Feedback ratio of

sampling has been 50% (see Table 5).As we compare the sampling and feedback of sampling with the universe; capital sum of automotive key industry manufacturers is 2.685.041.000 TL (*Otoyol* in stage of termination not included in total sum) while capital sum of automotive key industry manufacturers constituting the sampling is 1.946.156.000 (72,48% of overall sector). Capital sum of the sampling organizations that provided feedback is 1.155.000.000 TL (43,02% of overall sector). *Bosch Diesel*company is not included in these figures.

Since the structure of research surveys used hereby provides the same results when re-conducted by different researchers employing the same method, it is possible to form an idea regarding its reliability; however on accounts of its questionnaire structure as well as sampling size, it is not possible to conduct internal consistency tests. The best way to measure the reliability of this scale can be test-retest method.

Table 5. Research Sample

Name of Company	Province	Called for participation	Interview request was accepted	Participation to survey was accepted	Survey completed
ANADOLU ISUZU	Kocaeli	✓	**X**		
BMC	İzmir	✓	✓	✓	✓
BOSCH DİZEL	Bursa	✓	✓	✓	✓
FORD OTOSAN	Kocaeli	✓	✓	✓	**X**
HONDA TÜRKİYE	Kocaeli	✓	✓	✓	**X**
MERCEDES-BENZ TÜRK*	İstanbul	✓	✓	✓	✓
OYAK-RENAULT	Bursa	✓	✓	**X**	
TOFAŞ	Bursa	✓	✓	✓	✓

* Pilot study. ✓: Yes **X**: No

4.3. Evaluation of the data collected

The measurement results (scores out of one thousand total score) of technological innovation capabilities of business firms participated in the research are presented in Table 6 below.Amongst these companies that became comparable by eliminating organizational sizes, it is detected that code-B enterprise has, compared to the rest of enterprises, the highest technological innovation capability. However the scores received from this scale of which highest possible score is 1000 demonstrate that all participating organizations have low levels of technological innovation capability.

Table 6. Measurement results of technological innovation capabilities of the participating enterprises (company names have been concealed upon request).

	Enterprise A	*Enterprise B*	*Enterprise C*	*Enterprise D*
Input Factors Points	154,5	184	116	126,5
Process Factors Points	99	158	120	120
Output Factors Points	102	80	24	64
Total TIC Points(In Total 1000)	355,5	422	260	310,5

4.4. Evaluating the reliability of the proposed scale

As known, reliability means the consistent-definite measurement capacity of any measurement tool. A measurement tool is accepted to be reliable provided that it gives at all times the same result when measuring the feature aimed to be measured.As we evaluate the reliability of "technological innovation capability scale" formed in this research it is expected that since absolute data obtained from participator organizations have been stated on scale as clear-cut values, the very same results shall be reached once

the measurement is repeated. Furthermore it should be emphasized hereby that in measuring reliability, the frequency of conducting the measurements should be increased.

4.5. Evaluation of the proposed scale with respect to content validity

In content validity the primary aim is to examine to what extent factors constituting the scale reflect the feature that is aimed to be measured. One of the logical ways to employ in testing content validity is taking experts' views. Main and sub-factors that are present in the scale draft prepared in this research as well as grading and weighing scores of these sub-factors have been evaluated by an expert group. At the end of these studies by detecting appropriate/valid factors as well as their grades and weights the final form of the scale has been presented. Question forms that were prepared to gather data on these factors have also been examined and evaluated by the same expert team.

4.6. Evaluation of the proposed scale with respect to construct validity

A good number of issues in social sciences cannot be directly observable or measurable. Such issues are regarded as constructs by scientists and the success level of the available scales claimed to measure these constructs is questioned at all times. The primary point to consider in construct validity is to make sure that scale designers and participants (in present study, participants are directors) possess the very same definitions for the construct.In order not to degrade construct validity of TIC scale prepared for this study in the survey forms; "innovation strategy", "radical innovation", "incremental innovation" and similar structure-based concepts have been defined illustratively. Additionally since distance communication methods such as post, fax, e-mail have not been preferred in communicating with participant organizations, face-to-face interviews and survey methods have been employed and during such meetings comprehensive information has been rendered on the objective and scope of scale, particular care has been paid to make sure that all analyzed concepts at design stage be properly comprehended by the participants.

5. Conclusion

In the scope of this work; a model proposal and an innovation scale oriented to measure technological innovation capabilities of business firms in manufacturing industry sector had been formed. Studies on theoretical framework and meetings of consultative committee of experts guided the formation of the scale. With the scale prepared, a research project designed on automotive industry in Turkey by measuring technological innovation capabilities of primary industrial manufacturers in this sector.

Major reasons for the selection of the automotive industry in Turkey for the research are;

- Automotive industry is the third highest manufacturing industry in terms of rate of making technological innovation in Turkey [18].
- Automotive industry is one of the largest and long-established sectors of manufacturing industry in Turkey in terms of both total employment and total capital.
- This sector hosts both domestic and foreign capital in a heterogeneous manner.
- The serious increase of R&D and technology investments particularly after year 2000.
- The change in the approach of foreign capital about Turkish automotive sector; from assembly industry to manufacturing industry.

It is no question that the results regarding technological innovation capability of business firms obtained hereby shall not mean much when discussed on their own. Indeed what is aimed to be done through this can be likened to manufacturing a weighing scale that is expected to show the correct weight.

On the other hand when measurement results cannot be evaluated (when no feedback is received) it is obvious that the correctness or falseness of measurement results shall mean nothing with respect to measured value. To illustrate, the result of weighing or the information that a person receives about his weight after stepping on the scale can provide certain amount of information whether this person is healthy or not–at least in comparison to previous measurements-; likewise, the results obtained from this study and similar researches also attempt to put forth the reliability of the model or scale in this model but the results should also be effective in evaluating the measured feature and even in detecting the problems.

The fact that technological innovation capability scores of participant organizations are close to inverse proportion to foreign capital in their total capital may constitute a hypothesis for future studies.The technological innovation capability scores obtained hereby also underlines the fact that the reasons accounting for the low scores of technological innovation capability of automotive industry - which is one of the key components of manufacturing industry in Turkey- should be distinctively analyzed.It is considered that implementing the scale aimed to be developed hereby should be conducted in the headquarters of automotive manufacturers in foreign countries as well and obtained findings must be compared with the results of Turkey. It is also deemed to be useful that the scale should be conducted amongst different sectors and perform a cross-sectoral comparison as well.

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International Conference on Leadership, Technology and Innovation Management

A model proposal oriented to measure technological innovation capabilities of business firms – a research on automotive industry

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Abstract

In the scope of this work; a model proposal and an innovation scale oriented to measure technological innovation capabilities of business firms in manufacturing industry sector had been formed. Studies on theoretical framework and meetings of consultative committee of experts guided the formation of the scale. With the scale prepared, a research project designed on automotive industry in Turkey by measuring technological innovation capabilities of primary industrial manufacturers in this sector. The results of this research bring on the necessity of further studies about the low level of technological innovation capabilities in automotive industry.

Keywords: Innovation, Technological Innovation, Technological Innovation Capability, Innovation Scale, Automotive Industry

1. Introduction

Attributed to Galileo Galilei, the famous quote; "*Count what is countable, measure what is measurable. What is not measurable, make measurable*" is fundamental to modern management. In management terms, it translates as: "*You cannot manage what you cannot measure or do not measure*" [1]. In 1883, Scottish physicist, William Thomson (often referred as Lord Kelvin) expressed his idea in a lecture; "*I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be*" [2].

In accordance with these expressions and ideas above, we can come to a conclusion that we cannot manage technological innovation capability if we cannot measure or do not measure it. On the other hand, the complexities of innovational systems make them difficult to measure and thus increase the importance of the measurement system that will be used.

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2. Literature Review

2.1. Innovation

Innovation, perceived as a relatively new concept in management literature. Contrary to popular belief, innovation is not a new phenomenon. Arguably, it is as old as humankind itself. There seems to be something inherently "human" about the tendency to think about new and better ways of doing things and to try them out in practice [3]. In the history of social sciences, many scientists with various different perspectives had worked on this very old and well-established concept.

When we examine the etymology of the word "innovation"; we would discover the word "innovatus" as derived from Latin; in + novus meaning "make changes in something established" [4]. The root word; nova, (singular adjective of novus) means "new" and used to describe "a new star not previously known" in Latin. But those etymologic explanations are insufficient to explain and understand the meaning of innovation.

According to Schumpeter, "*To produce means to combine materials and forces within our reach. To produce other things, or the same things by a different method, means to combine these materials and forces differently*" [5]. He used the concept "new combinations" for this explanation. We can clearly see a strong relation between the meaning of innovation that we use today and Schumpeter's "*new combinations*". According to him, these "new combinations" can be; a new good that is one with which consumers are not yet familiar; a new method of production, that is one not yet tested by experience in the branch of manufacture concerned; a new market; a new source of supply of raw materials or half-manufactured goods; or a new organization of any industry. As can be seen clearly, innovation cannot be related only with "new goods".

Another perspective to innovation concept comes from Rogers and Shoemaker; innovation is an idea, practice or object perceived as new by an individual. It matters little, whether or not an idea is "objectively" new [6].

The Organization for Economic Co-Operation and Development's (OECD) document "The Measurement of Scientific and Technological Activities, Proposed Guidelines for Collecting and Interpreting Technological Innovation Data" (also known as the Oslo Manual), contains this definition of innovation; "*An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations*" [7].

In brief, innovation is a blend of strategic planning, research and development, marketing, project management, team work, training and creative thinking [8].

2.2. Relations between innovation and similar concepts

Many people confuse the terms innovation and invention. Indeed, if we ask people for an explanation we would collect a diverse range of definitions, because these terms are often used interchangeably. We can distinguish innovation from invention by suggesting that innovation is concerned with the commercial and practical application of ideas or inventions. Invention, then, is the conception of the idea, whereas innovation is the subsequent translation of the invention into the economy. The following equation helps to show the relationship between the two terms. "*Innovation = theoretical conception + technical invention + commercial exploitation*" [9].

Economically, inventing something is differentiate from the activity of innovation. The applicability and practicability of the invention or the creation is very important in order to talk about an innovation [10]. Noori, combines the concepts innovation, technology, invention and creativity as seen below [11].

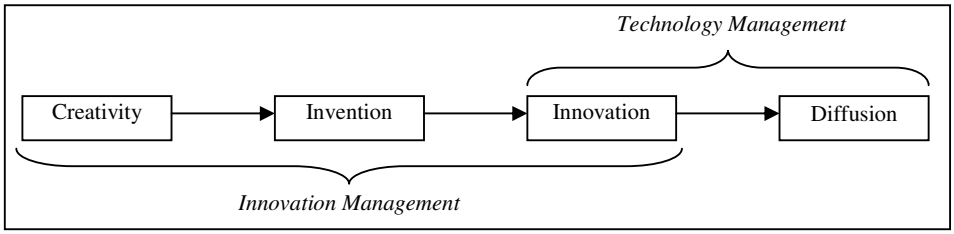

Figure 1. Relations between Creativity, Invention, Innovation and Technology

2.3. Technological innovation

Technological innovation is a sum of product (include services) and process innovations described above. The development of a new product or process, as well as major technological changes in existing products and processes must be considered in this context.

2.4. Technological innovation capability

Technological innovation capability (TIC) is a special asset of an enterprise, which comprises different key areas, such as technology, production, process, knowledge, experiences and organization [12]. Many authors highlight the different characteristics of mainstream and newstream processes [13]. Kanter argued that organizations are most effective where the different resource needs of the "mainstream" and "newstream" are recognized and their management largely autonomous. Managing business units in this way assists organizations in balancing the tensions of stability and change. An innovation capability is therefore defined as the ability to continuously transform knowledge and ideas into new products, processes and systems for the benefit of the firm and its stakeholders. Innovation capability is not just an ability to be successful at running a business newstream, or to manage mainstream capabilities. Innovation capability is about synthesizing these two operating paradigms [14].

3. Measuring Technological Innovation Capability

Measuring innovativeness is difficult to do well with a single measure because innovation can be achieved in many ways [15]. In the past, innovation measurement tended to be confined to R&D. This is frequently considered unsatisfactory since the innovation process also requires a number of non-R&D activities such as the acquisition of patents and licenses, design, training of personnel, market research and investment in new production capacity. While such non-R&D expenditure may be of considerable quantitative importance, innovation policy as well as theorizing and modeling still have to rely on R&D statistics as the major source of information systematically collected over time and across all OECD countries. In many of these countries, information about non-R&D expenditure on innovation is virtually nonexistent [16].

The European Innovation Scoreboard (EIS) is the instrument developed at the initiative of the European Commission, under the Lisbon Strategy, to provide a comparative assessment of the innovation performance of EU Member States. The EIS 2007 includes innovation indicators and trend analyses for the EU27 Member States as well as for Croatia, Turkey, Iceland, Norway, Switzerland, Japan, the US, Australia, Canada and Israel [17]. The innovation indicators in EIS 2007 are assigned to five dimensions and shown in the table below.

Table 1. EIS 2007 Indicators

1.INNOVATION DRIVERS (INPUT DIMENSION)
1.1 S&E graduates per 1000 population aged 20-29
1.2 Population with tertiary education per 100 population aged 25-64
1.3 Broadband penetration rate (number of broadband lines per 100 population)
1.4 Participation in life-long learning per 100 population aged 25-64
1.5 Youth education attainment level (% of population aged 20-24 having completed at least upper secondary education)
2.KNOWLEDGE CREATION (INPUT DIMENSION)
2.1 Public R&D expenditures (% of GDP)
2.2 Business R&D expenditures (% of GDP)
2.3 Share of medium-high-tech and high-tech R&D (% of manufacturing R&D expenditures)
2.4 Share of enterprises receiving public funding for innovation
3.INNOVATION & ENTREPRENEURSHIP (INPUT DIMENSION)
3.1 SMEs innovating in-house (% of all SMEs)
3.2 Innovative SMEs co-operating with others (% of all SMEs)
3.3 Innovation expenditures (% of total turnover)
3.4 Early-stage venture capital (% of GDP)
3.5 ICT expenditures (% of GDP)
3.6 SMEs using organizational innovation (% of all SMEs)
4.APPLICATIONS (OUTPUT DIMENSION)
4.1 Employment in high-tech services (% of total workforce)
4.2 Exports of high technology products as a share of total exports
4.3 Sales of new-to-market products (% of total turnover)
4.4 Sales of new-to-firm products (% of total turnover)
4.5 Employment in medium-high and high-tech manufacturing (% of total workforce)
5.INTELLECTUAL PROPERTY (OUTPUT DIMENSION)
5.1 EPO patents per million population
5.2 USPTO patents per million population
5.3 Triad patents per million population
5.4 New community trademarks per million population
5.5 New community designs per million population

Macro indicators (state level) of EIS shown in the table above, converted into micro indicators (business level) in this study. A consultative committee of experts had been constituted to guide this conversation process. The members of this committee were specialists from Turkish automotive sector and national academic institutions.

After studies on theoretical framework and meetings with consultative committee of experts, three factor groups; “input factors”, “process factors” and “output factors” determined for the measurement of technological innovation capabilities of business firms. Thereby the factors that overlooked by the traditional output-oriented measurement techniques would also taken into account. The factor groups, main factors in each factor group and number of sub-factors (determined to measure the main-factors) in each main factors and the percentages of each factor group decided by using factor scoring method can be seen in the Table 2 below.

Table 2. The factor groups, main factors in each factor group and number of sub-factors

Factor Groups	Points	Percent	Main Factors	Number of Sub-Factors	Points	Percent
Input Factors	360	36	Human Resource	10	75	7,5
			Knowledge Creation	4	120	12
			Vision and Strategy	8	55	5,5
			Entrepreneurship	8	110	11
Process Factors	230	23	Innovative Organization Culture	6	60	6
			Control	13	125	12,5
			Other process factors	3	45	4,5
Output Factors	410	41	Tangible Returns	6	160	16
			Intellectual Capital	8	250	25
	1000	%	*Total*	66	1000	%

Subsequent to preparing factor groups that measure technological innovation capabilities of organizations and also the main factors, the sub-factors deemed to be present within each single main factor have been determined. These sub-factors are as shown in Table 3 below. There are 66 sub-factors determined to measure the technological innovation capability of a business firm.

To ensure that these sub-factors can provide comparable results with the data gathered from organizations, utmost care has been paid to deal with numeric, objective and proportional factors which are at the same time the variables themselves.

Table 3. The Variables Prepared to Measure Technological Innovation Capabilities

			Degrees and Points					
Factor Groups	**Main Factors**	**Sub-Factors**	**WS***	**I**	**II**	**III**	**IV**	**V**
Input Factors	Human Resource	On the basis of total number of employees, number of higher education graduates below the age of 30 per 10 employees	5	1	2	3	4	5
		On the basis of total number of employees, number of engineering faculty graduates per 10 employees	5	1	2	3	4	5
		On the basis of total number of employees, number of Research&Development personnel per 10 employees	10	2	4	6	8	10
		Per person annual training duration of organization's directors	5	1	2	3	4	5
		Per person annual training duration of organization's white-collar employees	5	1	2	3	4	5
		Per person annual training duration of organization's blue-collar employees	5	1	2	3	4	5
		The ratio of per person annual training duration of organization's directors in themes such as innovation, creative thinking etc. to the length of total training	10	2	4	6	8	10
		The ratio of per person annual training duration of organization's white-collar employees in themes such as innovation, creative thinking etc. to the length of total training	10	2	4	6	8	10
		The ration of per person annual training duration of organization's blue-collar employees in themes such as innovation, creative thinking etc. to the length of total training	10	2	4	6	8	10
		The number of total personnel (%) that are deemed to be creative or potentially creative by directors	10	2	4	6	8	10
	Knowledge Creation	The ratio of direct R&D spending of the organizations in the last one year (With respect to total revenue of the last one year %)	60	12	24	36	48	60
		The ratio of employee training (education and development) spending of the organizations in the last one year (With respect to total revenue of the last one year %)	30	5	10	15	20	30
		The quality of organizational innovation-creation centered promotion and awarding system (if there is any)	10	0	2,5	5	7,5	10
		The extent of practicing organizational innovation-creation centered promotion and awarding system's outputs and the extent these practices turn into innovation	20	0	5	10	15	20
	Vision and Strategy	Whether the organization possesses a definite vision statement	5	0				5
		Whether the organization possesses an innovation strategy	10	0				10
		The extent of familiarity of such innovation strategy by directors	5	1	2	3	4	5
		The extent of familiarity of such innovation strategy by employees	5	1	2	3	4	5
		The extent of full understanding of such innovation strategy by directors	5	1	2	3	4	5
		The extent of full understanding of such innovation strategy by employees	5	1	2	3	4	5
		The extent of practicing such innovation strategy by directors	10	2	4	6	8	10
		The extent of practicing such innovation strategy by employees	10	2	4	6	8	10
	Entrepreneurs hip	The ratio of last one year's innovation spendings (excluding R&D) (With respect to total revenue of the last one year %)	40	8	16	24	32	40
		The extent of practicing the innovation types (Goods, Services, Process, Organizational, Business Model)	10	2	4	6	8	10
		The level of the density of innovation-oriented cooperations	10	2	4	6	8	10
		The contribution of the cooperation with an external partner on the basis	10	2	4	6	8	10

		of new idea creation in innovation projects over the process of innovation creation						
		The contribution of the cooperation with an external partner on the basis of product (good and/or service) development in innovation projects over the process of innovation creation	10	2	4	6	8	10
		The contribution of the cooperation with an external partner on the basis of process development over the process of innovation creation	10	2	4	6	8	10
		The contribution of the cooperation with an external partner over the process of developing all functions of the organization	10	2	4	6	8	10
		The quality of the financial or similar support received by the organization for innovation projects from various support foundations in the last four years	10	2	4	6	8	10
Process Factors	Innovative Organization Culture	The level of enthusiasm and willingness for innovation of the top management in the organization	15	3	6	9	12	15
		The level of enthusiasm and willingness for innovation of the middle and lower management in the organization	15	3	6	9	12	15
		The level of enthusiasm and willingness for innovation of the organization's white-collar employees	15	3	6	9	12	15
		The level of enthusiasm and willingness for innovation of the organization's blue-collar employees	5	1	2	3	4	5
		The level of promoting innovation creation processes, innovative business culture amongst sub-industry / supply industry companies that provide semi-finished products	5	1	2	3	4	5
		The level of promoting innovation creation processes, innovative business culture amongst companies that provide services such as security, cleaning, food	5	1	2	3	4	5
	Control	The percentage (if there is any) of completing the innovation projects within the specified duration by the organization during the last four years	15	3	6	9	12	15
		The percentage (if there is any) of completing the innovation projects within the specified budget by the organization during the last four years	15	3	6	9	12	15
		The percentage (if there is any) of completing the innovation projects within the specified quality standards by the organization during the last four years	15	3	6	9	12	15
		The frequency of receiving feedback on implemented innovation creation projects from the suppliers	5	1	2	3	4	5
		The frequency of receiving feedback on implemented innovation creation projects from the customers	5	1	2	3	4	5
		The frequency of receiving feedback on implemented innovation creation projects from research institutes and universities	5	1	2	3	4	5
		The frequency of receiving feedback on implemented innovation creation projects from specialist establishments on intellectual property rights	5	1	2	3	4	5
		The level that society appreciates innovation capacity of the organization	10	2	4	6	8	10
		The level that customers appreciate innovation capacity of the organization	10	2	4	6	8	10
		The level that suppliers appreciate innovation capacity of the organization	10	2	4	6	8	10
		The level that competitors appreciate innovation capacity of the organization	10	2	4	6	8	10
		The level that partners appreciate innovation capacity of the organization	10	2	4	6	8	10
		The level that organizational management itself appreciates innovation capacity of the organization	10	2	4	6	8	10
	Other process factors	The level that organization's "being innovative" factor is present in the processes that are within the scope of human resources management technique (work analysis, performance evaluation, pricing etc.)	20	0	5	10	15	20
		The frequency that organization takes part in national fairs which provide opportunity of promoting the new products (goods/services) in the market	10	2	4	6	8	10

		The frequency that organization takes part in international fairs which provide opportunity of promoting the new products (goods/services) in the market	15	3	6	9	12	15
Output Factors	Tangible Returns	With respect to total employee cost, the ratio of the decrease in labour force cost that occurs with the implementation of process innovation projects in organizations	20	4	8	12	16	20
		With respect to total production cost, the ratio of the decrease in operational costs that occur with the implementation of process innovation projects in organizations	20	4	8	12	16	20
		The break-even point duration of the organization's product (goods/services) groups from the stage of idea (project development) to the stage of retrieving the product (goods/services) from the market	10	2	4	6	8	10
		The revenue that the organization has received during the last four years from the sale of new products (goods/services) below age three	30	6	12	18	24	30
		The ratio of the revenue that the organization has received during the last four years from the sale of new products (goods/services) below age three to the total revenue received from the sales during the same period	40	8	16	24	32	40
		The ratio of the revenue that the organization has received during the last four years from the sale of new products (goods/services) below age three to the total spending on innovation creation activities during the same period	40	8	16	24	32	40
	Intellectual Capital	The number of certificates (%) received by the organization upon application for patent/useful model during the last four years	20	0	5	10	15	20
		The ratio of the certificates (%) received by the organization upon application for patent/useful model during the last four years to the number of Research&Development personnel	40	0	10	20	30	40
		The ratio of the international (EPO, Triad) patent/useful model certificates received by the organization during the last four years to the number of average annual Research&Development personnel	40	0	10	20	30	40
		The ratio of the industrial design certificate applications that were awarded with certificates during the last four years	40	0	10	20	30	40
		The ratio of the number of national industrial design certificates received by the organization during the last four years to the number of average annual Research&Development personnel	40	0	10	20	30	40
		The ratio of the number of international (EPO, Triad) industrial design certificates received by the organization during the last four years to the number of average annual Research&Development personnel	40	0	10	20	30	40
		Whether the organization has received any national innovation awards	10	0				10
		Whether the organization has received any international innovation awards	20	0				20
		Total	1000					1000

* WS: Weighing Scores

The functioning of the technological innovation capability measurement model that is put forth in current study is as explained in Figure 2.

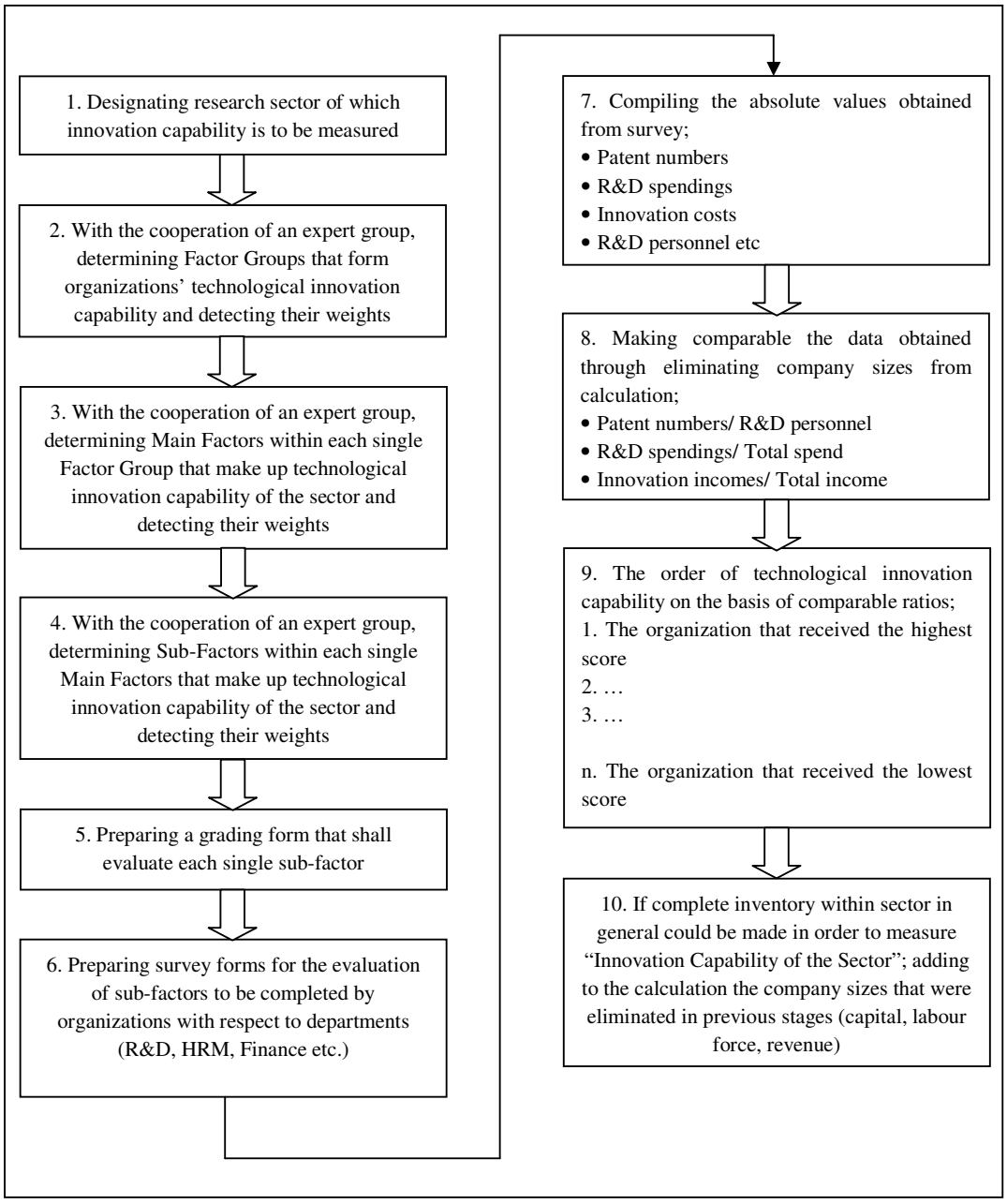

Figure 2. Functioning of Technological Innovation Capability Measurement Model

As stated in the explanation of the model above as well, subsequent to calculating factor score scale measuring technological innovation capabilities and comparable capability scores, if complete inventory within sector in general could be made, then the technological innovation capability score of the sector can be calculated.

The technological innovation capability score of the sector can be calculated as below; (In calculating technological innovation capability score of the sector with respect to paid amount of capital, total number of employees and total annual revenue the variables below stated shall be utilized).

Organization's score of innovativeness; I

Weighted organization innovativeness score; I'

Total innovativeness score of research sampling; SI

Total innovativeness score of the sector; TI

Organization's paid amount of capital; C

Research sampling's total paid amount of capital; SC = $\left(\sum_{1}^{n} C\right)$

Organization's total number of employees; E

Research sampling's total number of employees; SE = $\left(\sum_{1}^{n} E\right)$

Organization's total annual revenue; R

Research sampling's total annual revenue; SR = $\left(\sum_{1}^{n} R\right)$

$$I' = \frac{I \times C \times E \times R}{\left(\sum_{1}^{n} C\right) \times \left(\sum_{1}^{n} E\right) \times \left(\sum_{1}^{n} R\right)} \rightarrow \qquad SI = \sum_{1}^{n} I'$$

If the complete inventory of the research sector in general could be made; SI = TI is the result. In case complete inventory could not be made it is obvious that SI score to be obtained shall give an idea only to the extent that the scale represents overall sector.

Research

Research objectives, methodology, scope and constraints

The purpose of this study is implementing the model that has been developed to measure organizations' technological innovation capabilities on automotive key industry organizations in Turkey and then compile the obtained findings. Type of research is quantitative research. Data is gained with two approaches as distributing surveys in hand and in-depth interviews. Surveys and interviews are implemented in term of July-September 2008. Thus, the data collected is cross-sectional. Participation to research is relying on essence of voluntary. Turkish automotive industry was chosen as the scope of this research.

Since one single survey form would be filled with too many questions, three surveys addressing to three separate departments of each organization have been prepared (See Table 4).

4. Table 4. The Prepared Survey Types and Extensive Information on Surveys

	Survey Type	1st survey prepared for Human Resources Management departments of organizations	2nd survey prepared for Research and Development departments of organizations	3rd survey prepared for Administrative and Finance departments of organizations
Survey sub-sections	Cover and cover letter	Total two pages, except the title of the addressed department manager in cover letter, the text is literally the same with the rest of the surveys	Total two pages, except the title of the addressed department manager in cover letter, the text is literally the same with the rest of the surveys	Total two pages, except the title of the addressed department manager in cover letter, the text is literally the same with the rest of the surveys
	Descriptive information	**8** open and close ended questions	**5** open and close ended questions	**15** open and close ended questions
	The sections covering the information on model implementation	**11** open and close ended questions	**23** open and close ended questions	**5** open and close ended questions
	Total number of questions	**19** questions	**28** questions	**20** questions

One of the basic constraints of the research is the difficulty of the measurement of technological innovation capability because of the complex structure of innovations. A second constraint is the unwillingness of business managers to share all the information required by the survey and consequently low rate of return.

Research universe and sampling

The universe of present research consists of registered members of Automotive Manufacturers Association of Turkey (as of July 2008). Upon the termination of *Otoyol*, the number of organizations in universe was reduced to seventeen. Through judgment sampling method from this universe, organizations that can represent different sub-groups with respect to both capital size and capital ownership were selected and included within sampling which is manifested in Table 5. In addition to seven organizations that are included in sampling *Bosch Bursa Diesel* company that manufactures diesel equipment which is the most substantial by-industry product of automotive industry has also been included in sampling. Pilot study of the research has been conducted in *Mercedes-Benz Turk* company which was the first business firm visited within the scope of sampling. Subsequent to the pilot study conducted in this organization, certain changes and improvements have been made in survey forms.

It has been considered that there would be decrease in received feedbacks if specific surveys for Human Resources, Research & Development and Administrative/Finance departments of each eight organization were to be sent via fax, e-mail or post; hence face-to-face interviews have been deemed to be more favorable and applicable. In the initial attempts to conduct face-to-face interviews, *Anadolu Isuzu* company turned down the invitation call made to explain objective of the research and present the survey forms. *Tofaş, BMC, Ford Otosan, Oyak Renault, Mercedes Benz Turk, Honda Turkey* and *Bosch Diesel* companies accepted the call. Upon the meetings, *Oyak Renault* company –based on the company's pretaken organizational decisions- rejected participating in the research. The interviews conducted with *Tofaş, BMC, Ford Otosan, Mercedes Benz Turk, Honda Turkey* and *Bosch Diesel* have ended satisfactorily, organizational data-gathering process via survey has been initiated. Having failed to provide feedback in the preset data gathering stage of research, *Ford Otosan* and *Honda Turkey* companies have been excluded of the research; data gathering stage of the research has been completed with the data received from *Tofaş, BMC, Mercedes Benz Turk And Bosch Diesel* companies. Feedback ratio of sampling has been 50% (see Table 5). As we compare the sampling and feedback of sampling with the universe; capital sum of automotive key industry manufacturers is 2.685.041.000 TL (*Otoyol* in stage of termination not included in total sum) while capital sum of automotive key industry manufacturers constituting the sampling is 1.946.156.000 (72,48% of overall sector). Capital sum of the

sampling organizations that provided feedback is 1.155.000.000 TL (43,02% of overall sector). *Bosch Diesel* company is not included in these figures.

Since the structure of research surveys used hereby provides the same results when re-conducted by different researchers employing the same method, it is possible to form an idea regarding its reliability; however on accounts of its questionnaire structure as well as sampling size, it is not possible to conduct internal consistency tests. The best way to measure the reliability of this scale can be test-retest method.

5. Table 5. Research Sample

Name of Company	Province	Called for participation	Interview request was accepted	Participation to survey was accepted	Survey completed
ANADOLU ISUZU	Kocaeli	✓	**X**		
BMC	İzmir	✓	✓	✓	✓
BOSCH DİZEL	Bursa	✓	✓	✓	✓
FORD OTOSAN	Kocaeli	✓	✓	✓	**X**
HONDA TÜRKİYE	Kocaeli	✓	✓	✓	**X**
MERCEDES-BENZ TÜRK*	İstanbul	✓	✓	✓	✓
OYAK-RENAULT	Bursa	✓	✓	**X**	
TOFAŞ	Bursa	✓	✓	✓	✓

* Pilot study. ✓ : Yes **X** : No

Evaluation of the data collected

The measurement results (scores out of one thousand total score) of technological innovation capabilities of business firms participated in the research are presented in Table 6 below. Amongst these companies that became comparable by eliminating organizational sizes, it is detected that code-B enterprise has, compared to the rest of enterprises, the highest technological innovation capability. However the scores received from this scale of which highest possible score is 1000 demonstrate that all participating organizations have low levels of technological innovation capability.

6. Table 6. Measurement results of technological innovation capabilities of the participating enterprises (company names have been concealed upon request).

	Enterprise A	*Enterprise B*	*Enterprise C*	*Enterprise D*
Input Factors Points	154,5	184	116	126,5
Process Factors Points	99	158	120	120
Output Factors Points	102	80	24	64
Total TIC Points (In Total 1000)	355,5	422	260	310,5

Evaluating the reliability of the proposed scale

As known, reliability means the consistent-definite measurement capacity of any measurement tool. A measurement tool is accepted to be reliable provided that it gives at all times the same result when measuring the feature aimed to be measured. As we evaluate the reliability of "technological innovation capability scale" formed in this research it is expected that since absolute data obtained from participator organizations have been stated on scale as clear-cut values, the very same results shall be reached once the measurement is repeated. Furthermore it should be emphasized hereby that in measuring reliability, the frequency of conducting the measurements should be increased.

Evaluation of the proposed scale with respect to content validity

In content validity the primary aim is to examine to what extent factors constituting the scale reflect the feature that is aimed to be measured. One of the logical ways to employ in testing content validity is taking experts' views. Main and sub-factors that are present in the scale draft prepared in this research as well as grading and weighing scores of these sub-factors have been evaluated by an expert group. At the end of these studies by detecting appropriate/valid factors as well as their grades and weights the final form of the scale has been presented. Question forms that were prepared to gather data on these factors have also been examined and evaluated by the same expert team.

Evaluation of the proposed scale with respect to construct validity

A good number of issues in social sciences cannot be directly observable or measurable. Such issues are regarded as constructs by scientists and the success level of the available scales claimed to measure these constructs is questioned at all times. The primary point to consider in construct validity is to make sure that scale designers and participants (in present study, participants are directors) possess the very same definitions for the construct. In order not to degrade construct validity of TIC scale prepared for this study in the survey forms; "innovation strategy", "radical innovation", "incremental innovation" and similar structure-based concepts have been defined illustratively. Additionally since distance communication methods such as post, fax, e-mail have not been preferred in communicating with participant organizations, face-to-face interviews and survey methods have been employed and during such meetings comprehensive information has been rendered on the objective and scope of scale, particular care has been paid to make sure that all analyzed concepts at design stage be properly comprehended by the participants.

7. Conclusion

In the scope of this work; a model proposal and an innovation scale oriented to measure technological innovation capabilities of business firms in manufacturing industry sector had been formed. Studies on theoretical framework and meetings of consultative committee of experts guided the formation of the scale. With the scale prepared, a research project designed on automotive industry in Turkey by measuring technological innovation capabilities of primary industrial manufacturers in this sector.

Major reasons for the selection of the automotive industry in Turkey for the research are;

- Automotive industry is the third highest manufacturing industry in terms of rate of making technological innovation in Turkey [18].
- Automotive industry is one of the largest and long-established sectors of manufacturing industry in Turkey in terms of both total employment and total capital.
- This sector hosts both domestic and foreign capital in a heterogeneous manner.
- The serious increase of R&D and technology investments particularly after year 2000.
- The change in the approach of foreign capital about Turkish automotive sector; from assembly industry to manufacturing industry.

It is no question that the results regarding technological innovation capability of business firms obtained hereby shall not mean much when discussed on their own. Indeed what is aimed to be done through this can be likened to manufacturing a weighing scale that is expected to show the correct weight. On the other hand when measurement results cannot be evaluated (when no feedback is received) it is obvious that the correctness or falseness of measurement results shall mean nothing with respect to measured value. To illustrate, the result of weighing or the information that a person receives about his weight after stepping on the scale can provide certain amount of information whether this person is healthy or not–at least in comparison to previous measurements-; likewise, the results obtained from this

study and similar researches also attempt to put forth the reliability of the model or scale in this model but the results should also be effective in evaluating the measured feature and even in detecting the problems.

The fact that technological innovation capability scores of participant organizations are close to inverse proportion to foreign capital in their total capital may constitute a hypothesis for future studies. The technological innovation capability scores obtained hereby also underlines the fact that the reasons accounting for the low scores of technological innovation capability of automotive industry -which is one of the key components of manufacturing industry in Turkey- should be distinctively analyzed. It is considered that implementing the scale aimed to be developed hereby should be conducted in the headquarters of automotive manufacturers in foreign countries as well and obtained findings must be compared with the results of Turkey. It is also deemed to be useful that the scale should be conducted amongst different sectors and perform a cross-sectoral comparison as well.

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