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The impact of technology transfer performance on total quality management and quality performance

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Abstract

The purpose of this research is to define the critical factors of technology transfer performance (TTP) and to measure its impact on quality performance (QP) and total quality management (TQM). In this study, a questionnaire form was designed and later conducted face to face with manufacturing managers or quality managers of the manufacturing firms in Turkey. Two hundred organizations of the largest 1000 companies according to the classification of Istanbul Chamber of Industry have been evaluated. A model was developed to investigate the relationships among technology transfer performance, quality performance, and total quality management that is based on theoretical considerations. Technology transfer performance has a positive and strong impact on total quality management, but it has no significant impact on quality performance. A positive and strong relationship was determined between total quality management and quality performance. The relationship between technology transfer performance and quality performance has become significant with the mediating role of total quality management.

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Keywords - Technology transfer performance, total quality management, quality performance, Turkey.

1. Introduction

In today's global markets, there is tough competition among firms. Hence, firms must be able to meet their customers' demands and expectations satisfactorily. Because of these requirements, firms need to improve cost, delivery time, and quality. As a result firms must constantly develop their products, services, and processes. In order to achieve these developments, they are obliged to renew both their hardware and business processes. This regenerative process could be possible only with the help of technological development. Global competition, shortened product life cycles, and developments in manufacturing technologies compel manufacturing firms to compete in complex and dynamic markets. In continuously increasing competitive environment, the companies must improve their costs, quality, and delivery times to meet and even exceed customer needs and expectations in the best possible way. Technology has great importance for both competitive advantage of firms and development of countries. Technology transfer is the movement of technology from one site to another, namely from a university to an organization, from one organization to another, and from one country to another. If it is cheaper to transfer technology than to reproduce it, technology transfer is preferred. In today's competitive markets companies are required to obtain knowledge and new technologies from extrinsic environment. Thus, they take the advantage of their opinions and generate new products. Technology transfer

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is identified as the process for the former and following use of technology, know-how, facilities, and expertise for a specific goal (Verbano and Venturini, 2012).

Quality is one of the various competitive strategic instruments in businesses. Thus, companies have noticed that quality is an important major factors for developing products and services to encourage sustained achievement (Boateng-Okrah and Fening, 2012). In addition, technologies enable companies for developing high quality products and services. Nowadays, total quality management is a very important driver for the growth and success of companies in local and international markets. Implementing total quality management helps to increase the market share of companies and thus to improve their competitive capacity. Because customers demand better quality, lower prices, and quick response, improving the product and service quality of an organization is essential for business achievement. Total quality management is a management system and also an integrated philosophy, which improves the competitiveness of firms.

In the global competitive markets, total quality management and technology have become two of the important factors for business achievement and organizational growth. All departments in a company are compelled to act together toward the same goals in order to be successful in the market. Also, they must recognize that all employees and activities influence others, and in turn they are influenced by others. In order to improve competitiveness, companies search for a higher level of influence across all functions and processes. Companies implement total quality management and new technologies for staying in business. Total quality management and technology transfer performance have been studied individually so far, but the researches incorporating these are very rare. Thus, the exact nature of the links between these concepts has not been well clarified. The aim of this study is first of all to identify the critical factors of technology transfer performance, and then scrutinize the interrelationships among technology transfer performance, total quality management, and quality performance in Turkey. The second section in this paper presents relevant literature, research framework, and the hypotheses of the research. The third section provides research methodology, results, and discussion. Finally, the last section provides conclusions and implications.

2. Literature review and hypotheses development

The results of the literature search are presented in four sections to explain whether the relationship between technology transfer performance and quality performance is indeed mediated by total quality management. In the first section, the relationship between technology transfer performance and quality performance is scrutinized and in the second section the link between technology transfer performance and total quality management. Third section provides the literature on the relationship between total quality management and technology transfer performance. Finally, the mediating impact of total quality management on the relation between technology transfer performance and quality performance is explained.

Total quality management and technology become necessary factors for business achievement. A lot of companies use technology and adapt TQM for sustaining competitiveness. Technology performs a significant role in quality management. Therefore high-tech companies usually have better operational performance, quality performance and business performance than low-tech companies (Brah and Lim, 2006). Several researches have determined that TQM has a positive effect on customer satisfaction, financial outcomes, and quality (Boateng-Okrah and Fening, 2012; Karia and Asaari, 2006; Yang, 2006; Saizabitoria, 2005). According to Junior et al. (2014) companies can create new products that have better quality and lower costs by using new technologies. And also when developing new products, technology transfer is an efficient way of developing innovative skills (Jabar et al. 2011). Otherwise there is a relation between TQM implementation and quality performance (Talib et al., 2010; Arumugam et al., 2008). According to Sarina et al. (2009) firms' investment in quality implementation improves the technology transfer process. And also there is a relationship between total quality management and organization performance (Talib et al., 2010). Brah and Lim (2006) provided a relationship among quality management implementations, technology and performances. Talib et al. (2010) found also that there is a relationship total quality management and organization performance. Baird et al. (2011) state that TQM implementation impacts operational (inventory management and quality) performance. Thus, we may propose a similar assumption that total quality management plays the mediator role for the relationship between technology transfer performance and quality performance. Figure 1 illustrates the research model and the integration of technology transfer performance (TTP), total quality management (TQM) and quality performance (QP).

Technology is a combination of software, hardware and know-how, identifying the means by which we apply our understanding of the natural world to the answer of problems (Hirt, 2012; Miles, 1995). Technology transfer is the movement of technology by some channels from one organization to another. There are a lot of technology transfer

channels and methods. For example licensing, patent, know how agreements, books, journals, foreign investment, machinery, equipment, conferences, technical programs, industrial spies.
The process of technology acquisition has eight stages:

- Identification of technological needs,
- Obtaining information about alternative sources of technology,
- Dissemination of information,
- Evaluation and selection of the most suitable technology,
- Unpackaging of technology packages,
- Negotiation of the best terms and conditions,
- Adaptation and absorption of the imported technology,
- Optimum exploitation and maximum utilization of the technology.

For technology transfer performance the instrument used in this study was developed by Sung (2009), Lin et al. (2002), Souder et al. (1990) Mohamed et al. (2009), Trott et al. (1995), Guilfoos (1989), Wood and EerNisse (1992), Greiner and Franza (2003). Also we added 9 technology transfer success factors on the questionnaire. In our research there are 50 technology transfer success factors. Quality is a predictable degree of uniformity and reliability, at low cost and suited to the market (Demirbag et al., 2006; Deming, 1986). Competition increases and as a result changes have to happen. Therefore the better quality is needed by companies. New technologies may form better quality. Technology supports better quality and reducing product development costs. As an example in a technology transfer project, Toyota six state-of-the-art airjet looms to speed up manufacturing, to improve quality of products and to reach lower production costs (Junior et al., 2014). After literature review we determined the measures of quality performance. According to Ahire et al. (1996) the measures of quality performance are reliability, performance, durability and suitability of product standardization (Ahire et al., 1996). According to Kaynak (1997), the measures of quality performance are product / service quality, productivity, the cost of reproduce and waste product, suppliers' delivery time and on time delivery (Kaynak, 1997). According to Corbett and Rastrick (2000) the measures of quality performance are the percentage of defective material from the supplier, Total defects as a percentage of production volume, cost of quality (as example errors, scraps, reworks and inspections) as a percentage of total sales, warranty claims cost as a percentage of total sales, ratio of quality control inspectors to direct production operators, percentage delivery in full on time to customers (Corbett and Rastrick, 2000). Dean and Bowen (1994) suggest that quality performance increase when firms focus customer, continuous improvement and team work (Everett et al., 1997). Firms can meet their customers' expectation and needs satisfactorily by technology transfer. So after technology transfer firms can focus customer and firms' quality performance can be increased. According to Verbano and Venturini (2012), one of technology transfer's reason is quality control. Therefore technology transfer supports quality performance.

The measures of quality performance which we used in this research are product performance, product / service quality, productivity, on time delivery, product reliability, product durability suitability of product design specifications, product standardization, the percentage of defective material from the supplier, total warranty cost, ratio of quality control inspectors to direct production operators, the percentage of total waste product , suppliers' delivery time, the cost of reproduce and waste product. When companies use technology, they need less input and they have more output. So companies' productivity increases because of technology. After increasing productivity quality performance can be improve. On the other hand technology decreases firms' process time. Products can be produced quickly because of technology. As a result delivery time can become shorter. The cost of reproduce and waste product are decrease after using technology. So technology can affect quality performance.
Between technology transfer performance and quality performance we expect that:

H1: There is a positive relationship between technology transfer performance and quality performance.

Total quality management is purposed at incessantly making better for the quality and process to reach customer pleasure. Crosby (1979), Deming (1986), Feigenbaum (1983), Juran (1986) and others have developed certain formula in the field of quality management (Karuppusami and Gandhinathan, 2006). According to Claver et al. (2003), TQM provides companies, to acquire a high level of differentiation, providing customers' demand, improving brand image, to decrease costs by preventing errors and time wasting and permitting improvements in the processes of company (Claver et al., 2003). Leadership, strategic planning process, strategic quality management, process quality management, conception quality management, education and training, supplier quality management, customer satisfaction, employee responsibility and involvement, important innovation, quality results (business results), knowledge and analysis are measures which we used in this research. We adapted all TQM measures from Saraph et al. (1989). A relationship was provided between quality management practices and technology by Brah and Lim (2006). According to Merino and

Cerio (2003), the firms having more automation, they apply more quality management implementation. Based on the arguments that gathered from literature we hypothesize that:

H2: There is a positive relationship between technology transfer performance and total quality management.

In some empirical studies, positive relation between quality implementations and quality performance are identified (Adam, 1994; Flynn et al., 1995; Hendricks and Singhal, 1997; Kaynak, 2003; Powell 1995). Total quality management is a connective organizational-wide philosophy purposed towards continuously improving the product quality, service quality and process quality (Baird et al., 2011). Prajogo (2005) has indicated that the impact of TQM on quality performance is significant. Besides according to Salahedin and Mukhalalati (2009) after successful implementation of TQM, quality will be improved (Boateng-Okrah and Fening, 2012).

In the intense competition of contemporary business life, companies need to prove significant quality performance for survival. Claver et al. (2003) point out that total quality management permits organizations, to acquire a high degree of differentiation, providing customers' demand, improving brand image, to decrease costs by preventing errors and time wasting and permitting improvements in the processes of organizations (Claver et al., 2003). Todays many Turkish firms are actively pursuing TQM to improve their quality performance so that they can compete more effectively in market place (Bas, 2002). Prajogo (2005) found TQM's impact on quality performance in his research.

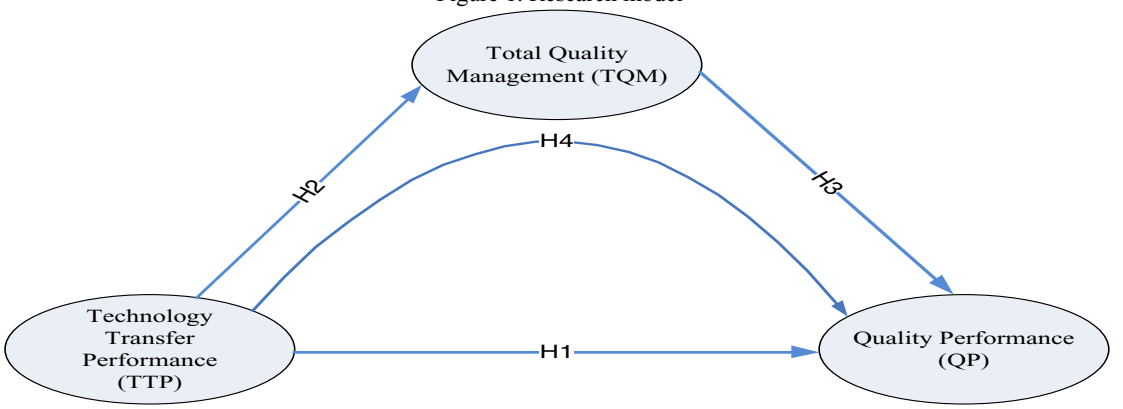
In Turkey companies have invested important resources in adapting and implementing total quality management to improve their performance (Alpkan et al., 2003; Demirbag et al., 2006). Demirbag et al. (2006) established relationship between TQM implementation and performance dimensions in their research. The relationship between total quality management and organizational performance has been investigated extensively in the previous literature (Demirbag et al., 2006; Ahire and Golhar, 1996; McAdam and McKeown, 1999; Yusof and Aspinwall, 2000; Cagliano et al., 2001; Sun and Cheng, 2002; Lee, 1998; Raymond, 2005; Dangayach and Desmukh, 2005). On the other hand there is not systematic empirical evidence concerning the effect of TQM implementation on quality performance. Total quality management in terms of improved firm's process, costs and increased productivity may actually help increase product performance which in turn has a positive impact on measures of quality performance. Flyyn et al. (1995) evaluated the effect of TQM practices on quality performance and competitive advantage. On the basis of conclusive evidence supporting a relationship between total quality management and quality performance, the following hypothesis is proposed:

H3: There is a positive relationship between an organization's total quality management and its quality performance.

Previous studies of quality management researched relation between total quality management and quality performance (Adam, 1994; Flynn et al., 1995; Powell 1995; Hendricks and Singhal, 1997; Kaynak, 2003; Prajogo, 2005; Salahedin and Mukhalalati 2009; Baird et al., 2011; Boateng-Okrah and Fening, 2012). But there is not any research about technology transfer performance's impact on quality performance with a mediating role of total quality management. The notion of total quality management mediating the relation between technology transfer performance and quality performance has its original conceptional grounding in the technology transfer and quality literature. Total quality management and technology perform an significant role in improving the firms' performance. When firms transfer a new technology, firstly they have to arrange their process. Because of technologies firms have to apply total quality management' dimensions. If firms' TQM implementation is successful, these firms' quality performance will be increase. As a result total quality management dimensions are equally significant and they are able to intermediate between technology transfer performance and quality performance. Hence, it is seen that total quality management plays a significant mediating role in rising the strength of the relation technology transfer performance and quality performance. Based on this discussion we hypothesize that:

H4: The impact of technology transfer performance on quality performance increases with a mediating role of total quality management.

Figure 1. Research model



3. Research methodology

3.1 Survey instrument

The questionnaire encompasses questions about three constructs. These constructs are technology transfer performance (TTP), total quality management (TQM) and quality performance (QP). Our measurement instrument was based on a review of the literature. For TTP the instrument used in this study was developed by Sung (2009), Lin et al. (2002), Souder et al. (1990) Mohamed et al. (2009), Trott et al. (1995), Guilfoos (1989), Wood and EerNisse (1992), Greiner and Franza (2003). Also we added 9 technology transfer success factors on the questionnaire. In the questionnaire there are 50 technology transfer success factors. To measure the dimensions of technology transfer performance, fifty items were measured using a five point Likert scale. For TQM the instrument used in this research was developed by Saraph et al. (1989). Respondents were asked to evaluate their firm's total quality management on five point Likert scale. In our research we used these TQM success factor's dimensions:

- Leadership (TQM1),
- Strategic planning process (TQM2),
- Strategic quality management (TQM3),
- Process quality management (TQM4),
- Conception quality management (TQM5),
- Education and training (TQM6),
- Supplier quality management (TQM7),
- Customer satisfaction (TQM8),
- Employee responsibility and involvement (TQM9),
- Important innovation (TQM10),
- Quality results (business results) (TQM11),
- Knowledge and analysis (TQM12).

For QP the instrument used in this study was developed by Ahire et al. (1996), Kaynak (1997) Corbett and Rastrick (2000). Quality performance items were measured using a five point Likert scale. The quality performance construct includes the following dimensions:

- Product performance (QP1),
- Product / service quality (QP2),
- Productivity (QP3),
- On time delivery (QP4),
- Product reliability (QP5),
- Product durability (QP6),
- Suitability of product design specifications (QP7),
- Product standardization (QP8),
- The percentage of defective material from the supplier (QP9),
- Total warranty cost (QP10),
- Ratio of quality control inspectors to direct production operators (QP11),
- The percentage of total waste product (QP12),

- Suppliers' delivery time (QP13),
- The cost of reproduce and waste product (QP14).

3.2 The Findings

In order to study the interrelationships among the constructs TTP, TQM, and QP, two hundred organizations of the largest 1000 companies according to the classification of Istanbul Chamber of Industry in Turkey were selected. We surveyed manufacturing companies that have been successful in technology transfer. In this research, a questionnaire form was designed and later conducted face-to-face with manufacturing managers or quality managers of the firms. Characteristics of participating organizations are shown at Table I.

Table I: Characteristics of the sample organizations.

Sectors	**Percent (%)**	**Activity Period**	**Percent (%)**
Food	15,5	0-6 year	2
Textile	15	7-16 year	13
Metals Industry	12,5	17-26 year	18,5
Automotive	11	27-36 year	24
Construction	7	37 year and upper	42,5
Machine and equipmnet	6,5	**Number of Personel**	**Percent (%)**
Paper, paper products publishing	6	= < 50	1,5
Energy	5	51 – 100	3
Chemicals	3,5	101 – 150	6
Plastic	3	151 – 200	3,5
Stone and clay products	2,5	201 – 250	5
Wood and furniture	2,5	251 > =	81
Drugs	2,5	**Technology Level**	**Percent (%)**
Mine and mine products	2	Low technology	57,5
Elektronic	1,5	Medium technology	30
Cleansers	1	High technology	12,5
Tobacco	1	**Firm**	
Agricultural chemicals	1	High Scale Firms	81
Glass	0,5	Low Scale Firms	19
Aviation	0,5	**Capital**	**Percent (%)**
		% 100Domestic	81
		% 100 Foreign	6
		Domestic – Foreign	13

Figure 2 illustrates the results of path model and regression weights. As shown in Table II, the relationship between technology transfer performance and quality performance is not significant (β = -0.191; p>0.1 (p =0.103)). The result does not support H1 that technology transfer performance has a direct and strong impact on quality performance. This result contrasts with the results of previous studies (Brah and Lim, 2006; Verbano and Venturini, 2012; Junior et al., 2014). Table I also presents the relationship technology transfer performance and total quality management. The standardized regression weight for the hypothesized relationship between TTP and TQM was found to be positive and significant (β = 0.840, p<0.001), confirming H2 that technology transfer performance had a strong positive direct impact on the total quality management. The result that there is a direct effect from technology transfer performance to total quality management supports the findings Brah and Lim's study (2006). The standardized regression weight for the direct relationship between total quality management and quality performance was found to be positive and significant (β = 0.799, p<0.001), indicating a strong support for H3 that total quality management had a positive and strong direct

impact on quality performance, as indicated in Table VI. Total quality management is important for a firm's quality performance. As a result, it is expected that firms emphasize to improve total quality management in order to improve quality performance. And this result supports the results of previous researches (Adam, 1994; Flynn et al., 1995; Powell 1995; Hendricks and Singhal, 1997; Kaynak, 2003; Boateng-Okrah and Fening, 2012; Baird et al. 2011; Karia and Asaari, 2006; Yang, 2006; Saizabitoria, 2005). As it is seen in Table I, quality performance is also indirectly influenced by technology transfer performance through total quality management. We found the standardized regression weight positive and significant ($\beta = 0.965$, $p<0.001$). This result provides a good assistance for H4. Hence, the impact of technology transfer performance on quality performance depends on the extent of relationship between total quality management and quality performance. So the relationship between technology transfer performance and quality performance has become significant with total quality management's mediating role. This result tends to be in conflict with the non-significant finding of the direct relationship between technology transfer performance and quality performance. This research's findings provide obvious support on how technology transfer performance affects quality performance.

Table II. Regression weights between constructs in the path model

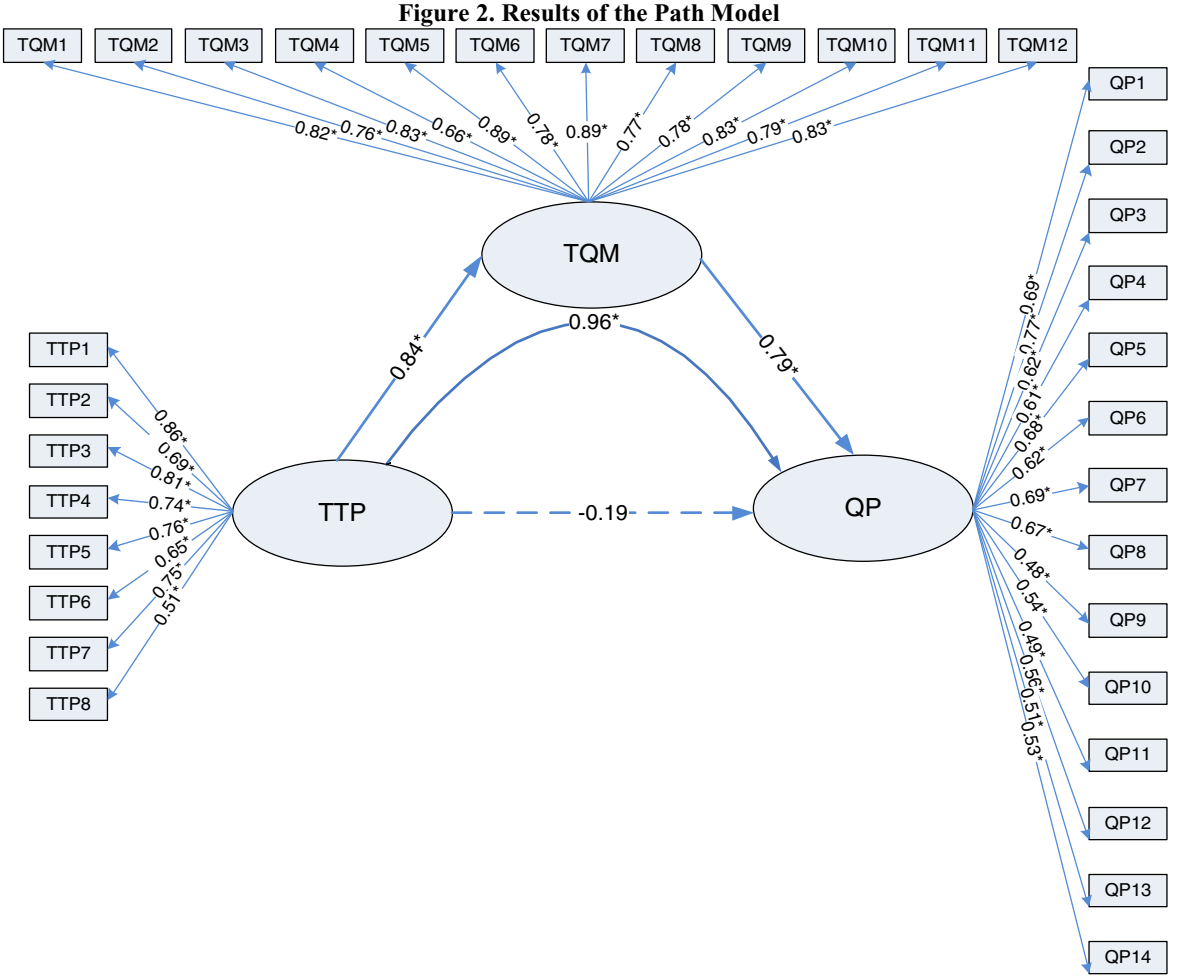
Hypothesis	Causal Path	Regression Weights
H1	Technology transfer performance - Quality performance	-0.191
H2	Technology transfer performance – Total quality management	0.840*
H3	Total quality management – Quality performance	0.799*
H4	Technology transfer performance - Quality performance (Through mediating impact of total quality management)	0.965*

*$p<0.001$

5. Conclusions and implications

The simultaneous interrelationships among technology transfer performance, quality performance, and total quality management have not been investigated in any research. This study's main purpose is to detect whether the relationship between technology transfer performance and quality performance is mediated by total quality management in manufacturing firms. Based on theoretical considerations, a model is suggested for to investigate the relations among the three constructs of technology transfer performance, quality performance and total quality management. Exploratory and confirmatory factor analyses are used on a sample of Turkish manufacturing firms to produce empirically verified and validated underlying dimensions of technology transfer performance construct. The results of structural equation modeling have revealed that although technology transfer performance had a positive and strong effect on total quality management, no significant direct relation was found between technology transfer performance and quality performance. In addition, a positive and strong relationship was identified between total quality management and quality performance. In the end, the findings provided empirical evidence that technology transfer performance leads to superior quality performance in the presence of total quality management. In other words, technology transfer performance has a positive and strong effect on the quality performance, considering the indirect route through total quality management. Hence, this result tends to approve the view that a triangulation of technology transfer performance, total quality management and quality performance outperforms two-way relationship between technology transfer performance and quality performance.

Figure 2. Results of the Path Model



Notes: * : Significance at 0.01 level.

The findings of this research present a number of administrative implications for firms. Many companies transfer technologies for have better products / services. Although technology transfer performance has a positive effect on total quality management, it has no effect on quality performance directly. Thus, technology transfer alone is not enough for better quality performance. If companies want to improve their quality performance by technology transfer, they must employ total quality management. Total quality management and technology transfer are essential for improving quality performance. In recent years, the role of technology increased for production and services. Technology became a production input such as capital and labor. Today, in the global competitive world, companies have to consider the importance of quality performance. For better quality performance, companies have to increase technology transfer performance and adopt total quality management. As the main result of this research, we have determined the dimensions of technology transfer performance. In order to determine this result, we searched previous studies about technology transfer. These are Sung (2009), Lin et al. (2002), Souder et al. (1990) Mohamed et al. (2009), Trott et al. (1995), Guilfoos (1989), Wood and EerNisse (1992), Greiner and Franza (2003). On the basis of the research search, we have identified 41 technology transfer success factors and added more. Thus in our research, there are 50 technology transfer success factors. After exploratory factor analysis, we defined 8 technology transfer performance dimensions. These dimensions are “effort for technology transfer, distribution of information and communication”, “new technology adoption and new technology implementation capability”, “care users in technology transfer and interaction with other organization about technology transfer”, “taking enough support for technology transfer”, “ambitious workers about technology transfer and technology which is chosen suitable for needs, adapt to environment’s condition”, “enough communication for technology transfer”, **“**organization which focuses management and help for technology users”,

"government's support for technology transfer and using technology that is transferred". Determination of technology transfer performance dimensions will be useful and contribute to technology transfer literature.

The results of this research will help firms notice the role of technology on TQM and quality performance and use technology to support sustained quality improvement efforts. We acknowledge that this study has a number of limitations. First of all, the data are collected from manufacturing firms in Turkey, which may limit to some extent generalizability of the results. Secondly, due to relatively small sample size, a caution should be exercised when evaluating the findings. Yet this research's findings present a base on which future study with larger sample sizes may build. Finally, utilization of other estimation methods, like neural networks, may provide further insights into the interrelationships among TTP, TQM and QP constructs.

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