COMPUTER-AIDED MANUFACTURING, JUST IN TIME PRODUCTION, TOTAL QUALITY MANAGEMENT AND USE OF BALANCED SCORECARD MEASURES: AN EMPIRICAL STUDY

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Bilgisayar Destekli Üretim, Tam Zamanında Üretim, Toplam Kalite Yönetimi Uygulamaları ve Dengeli Ölçüm Kartı Ölçülerinin Kullanımı: Ampirik Bir Çalışma

Özet

Performans ölçüm sistemleri modern üretim ortamlarının yüksek seviyeli rekabetçi özelliğine bağlı olarak değişmektedir. Dengeli Ölçüm Kartı'da söz konusu değişimin sonuçlarından biridir. Bu çalışmada yeni bir performans ölçüm sistemi olan DÖK'nın BDÜ, TZÜ ve TKY gibi üzerinde çokça tartışılan ve ön plana çıkarılan üretim ve yönetim teknikleriyle ilişkisi irdelenmeye çalışılmaktadır. Bu çerçevede Türkiye'de ilk beşyüz büyük işletme içerisinde gösterilen yüz yirmi iki imalat işletmesinden toplanan veriler kullanılarak, BDÜ, TZÜ ve TKY'nin çoklu performans ölçüm sistemi'yle nasıl bir ilişki içerisinde olduğu ampirik olarak incelenmektedir. Sonuçlar, performans değerlendirmeye yönelik çoklu ölçüm sisteminin kullanımı ile bilgisayar destekli üretim sisteminin, tam zamanda üretim ve toplam kalite yönetim uygulamalarına önem veren işletmeler arasında doğrusal bir ilişki olduğunu göstermektedir.

Anahtar Kelimeler: Dengeli ölçüm kartı, bilgisayar destekli üretim, tam zamanında üretim, toplam kalite yönetimi, lojistik regresyon analizi.

Abstract

Performance measurement systems have been altering according to the high-level competitive characteristics of modern manufacturing environments. Balanced scorecard is one of the results of these alternations. In this study the relationship between the balanced scorecard as a new performance measurement system and the production and management techniques such as Computer Aided Manufacturing(CAM), Just in Time(JIT) and Total Quality Management(TQM) that have been largely discussed and kept in the forefront will tried to be explicated.

In this frame, by using the data collected from 122 manufacturing businesses among the first 500 large businesses in Turkey in the year 2006, this paper examines how a multiple performance measurement system is associated with applications of CAM, JIT and TQM. The results show that greater emphasis on the usage of a multidimensional performance measurement system directed at performance evaluation is associated with making greater use of CAM, JIT and TQM system.

Keywords: Balanced scorecard (BSC), computer aided manufacturing (CAM), just in time (JIT), total quality management (TQM), logistic regression analysis.

Computer-Aided Manufacturing, Just in Time Production, Total Quality Management and Use of Balanced Scorecard Measures: An Empirical Study

INTRODUCTION

High competition and changes in manufacture technologies lead to advanced production and management techniques as computer-aided manufacturing (CAM), Just in Time Production (JIT) and Total Quality Management (TQM). Therefore, the meaning and content of performance measurement as a concept is deepened and expanded with these technics. Multiple performance measurement system can be seen as a result of these developments.

In modern business administration history, performance measurement is examined differently in two terms. The first include almost a century from 1880s to 1980s. The second is an ongoing period from 1980s until today in which the results of radical changes occurred in world markets. In the first period, largely financial measures such as profit, investment return and productivity were emphasized. In the second period, because of flexible, dynamic and process-focused production environments, non-financial measures are added to financial measures.

With these production and management technics, there is a transition from traditional performance measurement system based on financial measures to multiple performance measurement system (BSC) based on financial and non-financial measures at the same time. This transition is largely depend on that these measures support the following main variables such as increasing quality of product and service, continuous improvement and reducing the wastes predicted in production and management techniques (Hendrikcs, 1994:

27; Cheatham/Cheatham, 1996; Wruck/Jensen, 1998: 401-423; Upton, 1998: 110).

In this context, it's easy to see that balanced scorecard (BSC) is compatible with the expectations from a performance measurement system (Kaplan/Atkinson, 1998:367-375; Kaplan/Norton: 1996; Kaplan/Norton, 2001; Kaplan/Norton, 1992; Atkinson et al., 2004; Simons, 2000: 202; Durden et al., 1999: 111-125) and also presents required instruments providing correct directions to the future.

BSC can meet the production and management requirements because of its following qualifications: (1) focusing long term perspective instead of short term perspective; (2) presenting data both in financial and non financial/operational dimensions; (3) being timely and ready for usage instead of being prepared for terms; (4) being easy to understand and apply; (5) immediately answering/ adapting the changes in the production process, (6) transforming the firm strategy to operational measures (Santari, 1987: 27).

Hitherto studies on this subject show that the usage of multiple performance measures by the firms are directly related with the variables like market competition, computer aided production, management techniques, the structure of a firm (size, culture, technological situation and assimilated strategy etc.) and the included sector. In this study, the aim is to determine whether or not the multiple performance measures are used, especially in the manufacturing firms of first 500 firms in Turkey and if so, to identify the relationships among CAM, JIT, TQM techniques and multiple performance measures.

The remainder of this paper is organized as follows. The next two sections examine the literature related to the subject, define the main variables, and present a set of hypotheses. The methodology which include the sample definition, data collection and analysis of data, and the results of logistic regression analysis is presented in the following section. The final section includes a discussion of the results of this study.

1. CAUSAL FACTORS ON USING BSC MEASURES

Many factors contribute to why many firms prefer non-financial performance measures. According to this, while some researchers suggest that the preference for these measures on a large scale is related to the enterprises operational and competitive structure (SAID et al., 2003: 193-223), the others suggest that this preference can be related to JIT, TQM and CAM structure (Hoque/Mia, 2001: 23-45). Similarly, while many reported that the use of

multiple performance measures is relevant only to the strategic preference of managers' (Malina/Selto, 2001:48; Govindarajan/Gupta, 1985: 51-66), some reports demonstrate that an enterprise's environmental conditions affect this preference. On this subject, for example, Hoque (2004: 485-502) found that there was a meaningful relationship between environmental uncertainties and preference of these measures, Chenhall and Morris (1986: 16-35) found that organizations have the tendency to prefer non-financial management accounting systems in order to cope with high environmental uncertainty effectively.

The use of multiple performance measures and its positive effects on the production performance are comprised in another section of this related literature. For example, while Banker, Potter and Schroeder (1993: 33-55) state that the multidimensional performance measurement system reports presented to the personnel in production line was positively associated with the implementation of the modern management techniques such as JIT, Team Work and TQM. However, Chenhall (1997: 187-206), Jeffrey (2005: 271-309) and Ittner/ Larcher (1995: 1-34) examined the use of BSC together with the aforementioned modern techniques and argued that enterprises using the TQM/JIT and non-financial (production performance) measurements together have reached a higher performance than other firms without these measurements. Similarly, Abernethy/Lillis (1995: 241–258) and Young/ Selto, (1991: 265-298) found that CAM had a positive relationship with the measures such as cost, quality, time.

Additionally, many studies examine the positive contribution of multiple performance measures on the general enterprise performance from the financial perspective. For example, while Davies/ Albright (2004: 135-153) and Dilber et al.(2005: 220) argued that there is a meaningful positive relationship between the use of BSC and high level financial performance. In an empirical study by James, Hoque (2000: 1-17) demonstrates that the use of BSC increases general enterprise performance, but this increase is not associated with organization size, product life circle, or market position. Lingle and Schiemann (1996: 56-61) found found that enterprises managed by measurements reached a higher financial performance level, a higher industrial position and a higher level in the management process relative to enterprises that are not managed by measurements. Ittnera, Larckera and Randalb (2003: 715-741) indicated that the enterprises placing more emphasis on measurement and variety have acquired a much higher stock exchange income. Perera, Harrison and Poole (1997: 557-572) argue that the use of non-financial measures show significant associations with customer focused strategy, but not the link to organizational performance.

Apart from studies examining BSC effects on general enterprise performance, other studies have examined the enterprise's suitable working conditions as an effective performance measurement tool in BSC. For instance Cavalluzzo and Ittnera (2004: 243-267) state that the organizational factors as such willingness in the top management directed at the use of performance knowledge, decision making and training in the subject of performance measurement techniques have a positive effect on the measurement system development and usage. Also, Moers (2005: 67-80) called significant attention to the positive relationship between the variety of performance measures and the degree of perfection with bias during the performance evaluation. It is clear that the bias mentioned here indicates a pre-cognitive accumulation directed at performance measurement.

On the other hand, Krumwiede (1998) suggested that organizations with higher quality information systems can implement new measurement systems comfortably relative to companies with less sophisticated information systems. Thus, he suggests that this highlights the linear relationship between opportunities for existing information systems and the success of implementation. In addition, he draws attention to managers, who are satisfied with information from the existing system that might not be willing to invest in new systems. This will give way to the development of a negative relationship between the system and its implementation.

Briefly, these studies argue that the usage of BSC by the firms associated with the manager's preference, specifically, the enterprise manager's scientific level, organizational culture, environmental conditions, technological developments, new management techniques, enterprise performance and indirectly, stock exchange incomes. The next section explains the main variables and present hypotheses.

2. VARIABLES AND HYPOTHESIS

2.1. Balanced Scorecard

Balanced scorecard developed firstly by Kaplan and Norton in 1992 can be described as a model or mechanism which translates an organizational's mission and strategy into operational goals and measures. BSC does not focus solely on achieving financial objectives. It also highlights the non-financial objectives that an organization must achieve in order to meet its financial objectives (Horngren et al., 2000:463). BSC can be classified in four basic dimensions as financial, customer, internal business processes, learning and growth (Kaplan/Atkinson, 1998: 367-375). Answers from following questions

obtained from four basic dimensions by business are used for constructing BSC (Atkinson et al., 2004: 356).

Financial performance dimension is identified with the question that "how is success measured by our shareholders?" At this point, the aim is describing the economic consequences of actions including the other three dimensions. Therefore, each selected measure need to be a part of the cause-and-effect relationship leading to an improvement in financial performance. These measures are such as operating income, sale amount, market share, new customers, new markets, cash flow, return on investment, etc. (Morrow, 1992: 145).

Customer dimension is formed with the question "how do we create value for our customers?". So, the prior subject of managements is that how business create value for customers and what activities can be realized for this aim. Also, in this dimension of the BSC managers identified the customer and market segments in which the business desires to compete. In this context, it is possible to list these basic measures as customer satisfaction, costumer loyalty, gaining new customers, customer profitability, and market and customer shares in targeted scope.

Internal business process dimension is formed with the question "at what internal business processes must we excel to satisfy our customers and shareholders?" In this dimension, managers identified the critical internal business process for create value both for customers and shareholders. These internal processes measures include number of new products or services, new product development times, number of new patents, sales percentage of new products, defect rates, yield, duration of production, production cost, setup time, manufacturing downtime and just-in-time delivery, etc.

Learning and growth perspective is shaped with the question "what employee capabilities, information systems, and organizational climate do we need to continually improve our internal processes and customer relationships?" Learning and growth measures constitute the idea that achieving the targets related with financial, customer and internal processes highly depend on the learning and growth capability of the organization. In the learning and growth measures, in particular that which one of roads is seen necessary for the development of internal operation methods is questioned and measured. Learning and growth measures contain that employee satisfaction scores, employee turnover rates, employees productivity, information system availability, percentage of employee suggestions implemented, percentage of compensation based on individual and team incentives.

2.2. Computer Aided Manufacturing (CAM)

Today, inreasing competition level in markets require using CAM[1] systems that enable firms to manufacture quality products for customer demands in a short time. Using CAM systems in manufacturing processes has brought about important changes in firms' performance measurement systems. This changing is seen more clearly if the literature related with this subject is examined.

In literature general approach to performans measurement systems is based on the theoretical frame that different manifacturing environment needs to different sorts of measures to assess organizational effectiveness (Bruggeman/Slagmulder, 1995: 241-252; Duncan, 1972: 313-327; Khandwalla, 1972: 275-285; Mia/Chenhall, 1994: 1-13). According to this, it's possible that many performans measures which comply with labour-intensive manufacture environment cannot show harmony with CAM, and more than this these measures by hiding realities about effectivity and productivity of production cause to rule benefits of investment out.

Just an other important subject is a necessity of improving performance measurement systems multidimensionally because there is a general shared think that performans measurement systems need to give opportunity to chase business processes in CAM rationally and value creation process to managers and employees. In short, opposite of traditional approach, in CAM, non-financial performans measures have an important status today because they can emphasize some items such as customer satisfaction, efficiency, innovation and labour productivity. Hence, that updating traditional performance measurement system for mentioned critical success factors is a requirement.

2.3. Just-In-Time Production

JIT is a production and inventory control system in which materials are purchased and units are produced only as needed to meet actual customer demand (Garrison/Noreen, 2000: 34). Four main characteristics of JIT can be ordered like these: 1) eliminating non-value creation activities to product or service, (2) focusing on high level quality and making right things at first time, (3) focusing on continuous improvement of efficiency of activities and (4) identifiying non-value creation activities, activities simplification and increasing examinations in the process (George/Horngren, 1987: 19).

1 CAM is the use of computers to plan, implement, and control production.

When we consider these characteristics we can say that traditional performance measurement system is not functional for JIT practices. Because in JIT manufacturing environment, the main purpose is to provide production flow with as far as little party and to decrease stock levels at least by considering continuous improvement. So, traditional production and productivity measures report in low level when production is in the form of little parties, traditional understanding can going away from basic aim (Drury, 1990: 40-41). In the same way, also traditional accounting system like standart costing cannot provide suitable operational control in today manufacturing environments (Allott, 2000: 54-56). As known, all these insuffiencies grow out of JIT production systems that make important changings in form of works of business and necessity of information (Upton, 1998: 110).

2.4. Total Quality Management

TQM is a popular approach that represents the standardization and streamlining of key operating processes to ensure high levels of quality and/or low defect rates (Simons, 2000: 772). This popular approach's success depend on submitting performance evaluation of operational activities to managers continually.

BSC is compatible with expectations from any performance measurement system in the context of TQM. Because there is a reciprocal relationship between BSC and TQM to activate TQM practices. BSC enhances the effectiveness of TQM programs in several ways (Kaplan/Norton, 2001: 376). Firstly, BSC identify internal processes and activities in which improvement will be most critical for strategic success. Furthermore, it can determine whether improving processes focus on important subjects such as cost decreasing, shorting production circle and improving quality.

Secondly, BSC define non-financial quality measures belongs to quality cost and prepare daily based and real time based reports and can determine real reasons of unrealizable operations as expected at that time (Sinclair/Zairi, 2000: 156-157). Thirdly, BSC can compel managers to construct business process providing successful outputs and to create value to customers and shareholders. In this way, it's possible to make continual relationship between quality and financial output. Also, using BSC by firms practicing TQM, make possible to obtain desirable outputs and to adapt to changing internal and external environment conditions more easily.

In this study, we argue that CAM, TQM and JIT applications encourage using non-financial performance measures more than using financial performance measures, some hypothesis can be ordered like those;

Multiple performance measures are associated with (a) a greater application of computer-aided manufacturing processes and (b) a greater application of just in time production and (c) a greater application of total quality management.

3. METHODOLOGY

3.1. The Nature of the Research and Sampling

This study depends on questionnaire distributed to 430 manufactures of the top 500 in Turkey. The questionnaires were delivered between the dates of 01 january-30 June 2006 by postal service and e-mail to the top managers (general manager or vice general managers) of the manufactures which participated in this study. The response rate was % 28.3 (122 responses out of 430 firms contacted). The manufacturing activity of the firms is depicted in Table 1.

Table 1: Profile of respondents by manufacturing activity

Manufacturing Activity				
1 Textile, clothing and footwear	25	20,5	20,7	20,7
2 Food and allied products	15	12,3	12,4	33,1
3 Drink and tobacco	1	,8	,8	33,9
4 Construction	10	8,2	8,3	42,1
5 Petroleum and chemicals	12	9,8	9,1	51,2
6 Plastic products	6	4,9	5,0	56,2
7 Metal Wares	6	4,9	5,0	61,2
8 Machinery	13	10,7	10,7	71,9
9 Wood and paper products	7	5,7	5,8	77,7
10 Automotive and spare part	20	16,4	16,5	94,2
11 Glass prodcts	1	,8	,8	95,0
12 Electronic products	6	4,9	5,0	100,0
TOTAL	121	99,2	100,0	

As can be seen from the table, manufacturing activity distribution was realised in the following order, 20.7% textile, clothing and footwear, 16.5% automotive and spare parts, 12.4% food and allied products and 10.7% machinery Sector.

3.2. Data Collection Tools

The survey form, which was developed to collect the research data, was comprised of two parts. In the first part, it is aimed to define the usage levels of CAM, JIT and TQM implementations. Within this framework, participants were requested to designate their choose "not used", "partly used", "used", "rather used" and "used at high level". And in the second part, the diversity of measurement is measured with an adapted version of the instrument used by Hoque and James (2000) and Hoque et al. (2001). The aforementioned BSC instrument consists of 20 items forming four sub dimensions such as "financial", "customer", "internal business processes" and "learning and growth". The participants were requested to designate whether their enterprises used the aforementioned measures. For this, the likert scale, in which the choices between 1 and 5 were "not used at all", "partly used", "used", "used rather a lot", and "used very much".

3.3. Data Analysis

In this study, the data was entered into SPSS 13 for data analysis. The reliability test, the factor analysis, the multi-correlation and the logistic regression analysis were performed.

3.3.1. Reliability Analysis and Descriptive Statistics for The Performance Measurement Items

The reliability analysis was performed to test the consistency of BSC's survey results. Cronbach alpha coefficient was found to be 90%. Together with this, no variable was negatively associated with the total correlation. The data showed strong internal consistency.

In Table 2, the descriptive statistical data related to performance measures usage are illustrated. According to this data, the enterprises' usage level of financial performance measures changed between 2 and 5, the average was 4.283. The usage level of customer performance measures ranged between 1 and 5, the average was 3.86. The usage level of internal business processes measures ranged between 1 and 5, the mean was 3.796. Lastly, the usage level of learning and growth measures ranged between 1 and 5 and the average was

3.195. The data obtained show us that the enterprises' financial performance measures were used at a very high level. The customer and internal business processes measures were above average and the learning and growth measures were below average.

Table 2: Descriptive Statistics for The Performance Measurement Items

Performance Measurement Items					
Financial Performance Measures					
Operating income	122	2	5	4,54	,729
Sales growth	122	2	5	4,42	,801
Return-on-investment	122	2	5	3,89	,977
Internal Business Process Measures					
Rate of material scrap loss	120	1	5	3,58	1,120
Ratio of good output to total output at each production process	121	1	5	3,88	1,119
Manufacturing lead time	120	1	5	4,14	,910
Materials efficiency variance	121	1	5	3,69	1,133
Labour efficiency variance	121	1	5	3,69	1,033
Learning and Growth Measures					
Number of new patents	118	1	5	2,57	1,349
Number of new product launches	121	1	5	3,26	1,209
Time-to-market new products	120	1	5	3,29	1,111
Employee satisfaction	122	1	5	3,66	1,134
Customer Performance Measures					
Market share	122	1	5	4,10	,948
Customer response time	120	1	5	4,20	,866
On-time delivery	122	1	5	4,02	,931

Number of customer complains	122	1	5	4,19	,982
Number of warranty claims	118	1	5	3,34	1,428
Survey of customer satisfaction	122	1	5	4,11	,911
Percentage of shipments returned due to poor quality	119	1	5	3,63	1,255
Number of overdue deliveries	120	1	5	3,29	1,219
Valid N	107				

3.3.2 Factor Analysis

Exploratory factor analysis was used to designate the factors which form the sub dimensions of BSC. Firstly, KMO (Kaiser-Meyer-Olkin) sampling adequacy measure was calculated for determining the convenience of data for factor analysis. KMO varies from 0 to 1. This measure shows that sampling is convenient for factor analysis when it is close to 1 and it shows that sampling is not convenient for factor analysis when it is under 0.50. In the analysis the KMO sampling sufficiency has been calculated as 0.803, this shows that this sampling has sufficient size.

Factor analysis has been carried out by using basic components and varimax rotating technique. The obtained factor analysis results were examined, because the factor burden related to the market share measure in the second and third factors and the factor burden related to the employees satisfaction measure in the second and fourth factors have almost the same burdens, analysis has been done again excluding these two variables.

At the end of the analysis, 5 factors have been determined whose eigenvalue is above 1. Five factors explained 69.857 % of the total variance. Factor 1 explained most proportion of the total variance (17.098 %) and consisted of variables which contained “internal business processes measures”. Factor 2 explained 14.381% of the total variance and consisted of variables which were related to “customer performance measures-I”. Factor 3 explained 13.582% of the total variance and consisted of variables which were related to “financial performance measures”. Factor 4 explained 13.495% of the total variance and factor 5 explained 11.301% of the total variance and they consisted of variables which were related to “learning and growth measures” and “customer performance measures-II”, respectively. Table 3 shows groups of questions.

Table 3: Rotated Component Matrix

Performance Measurement Items					
Internal Business Measures					
Rate of material scrap loss	,839				
Ratio of good output to total output at each production process	,748				
Manufacturing lead time	,667				
Materials efficiency variance	,613				
Labour efficiency variance	,546				
Customer Performance Measures-I					
Customer response time		,745			
Number of warranty claims		,694			
On-time delivery		,662			
Survey of customer satisfaction		,609			
Number of customer complains		,562			
Financial Performance Measures					
Sales growth			,873		
Operating income			,827		
Return-on-investment			,576		
Learning and Growth Measures					
Number of new product launches				,831	
Time-to-market new products				,824	
Number of new patents				,736	
Customer Performance Measures –II					
Percentage of shipments returned due to poor quality					,774
Number of overdue deliveries					,742

3.3.4. Average Values Related to the Variables and Correlation Analysis

In Table 4, the BSC and sub dimensions' averages, minimum, maximum values and standard deviations of the enterprises are presented. According to this, the enterprises usage points of overall multidimensional performance measures are between 38 and 100; the average usage point was 74.751. When the BSC sub dimensions were analyzed, the financial measures are between 6

and 15 and the average was 12.8525. The customer measures usage points were between 17 and 40 and the average was 30.5656. The internal business processes measures usage points varied between 7 and 25 and the average was 18.9174. The learning and growth measures usage points were between 4 and 20 and the average was 12.6148. These average figures show us that the enterprises use the financial performance measures (86%), customer performance measures (76%), and internal business processes measures (75%) are at a rather high level, learning and growth measures are at a medium level.

Table 4: BSC and Sub Dimensions Averages, Minimum, Maximum Values

Variables								
CAM	118	1	1-5	1	5	4,14	,951	
JIT	117	1	1-5	1	5	3,57	1,191	
TQM	121	1	1-5	1	5	4,08	1,144	
Overall Multidimensional Performance Measures	122	20	20-100	38	100	74,7951	12,64842	,905
Financial Performance Measures	122	3	3-15	6	15	12,8525	2,07970	,762
Customer Performance Measures	122	8	8-40	17	40	30,5656	5,46361	,787
Internal Business Measures	121	5	5-25	7	25	18,9174	4,23396	,849
Learning and Growth Measures	122	4	4-20	4	20	12,6148	3,88352	,813

In Table 5, the correlations between CAM, JIT, TQM and BSC's sub dimensions are presented. The numbers which are marked with an asterix in the table show that according to significance level 1% and 5%, there is a

meaningful relationship between the variables. As proposed, the overall use of multiple performance measures is positively and significantly correlated with CAM, JIT, TQM and the correlations were 0.462 ($p<0,01$), 0.442 ($p<0,01$), 0.537 ($p<0,01$), respectively. Also, table 5 displays that CAM, JIT, TQM are positively and significantly associated with the four performance dimensions.

Table 5: Multi Correlation Analysis

Variables									
CAM	1	,551**	,553**	,462**	,386**	,479**	,400**	,241**	,244**
JIT	,551**	1	,589**	,442**	,468**	,375**	,264**	,328**	,179
TQM	,553**	,589**	1	,537**	,380**	,444**	,454**	,338**	,415**
Overall M.P.M.	,462**	,442**	,537**	1	,792**	,702**	,674**	,705**	,635**
Financial Performance Measures	,479**	,375**	,444**	,702**	,525**	1	,366**	,414**	,403**
Customer Performance Measures-I	,241**	,328**	,338**	,705**	,414**	1	,403**	,380**	,321**
Internal Business Measures	,386**	,468**	,380**	,792**	,525**	,403**	1	,324**	,534**
Learning and Growth Measures	,400**	,264**	,454**	,674**	,366**	,380**	,324**	1	,321**
Customer Performance Measures-II	,244**	,179	,415**	,635**	,403**	,321**	,534**	,321**	1

** *Correlation is significant at the 0.01 level (2-tailed).*

3.3.5 Logistic Regression Analysis

In this section, how the usage of BSC measures showed a difference according to being CAM/JIT/TQM or non-CAM/JIT/TQM firm will try to be explained. For this purpose, the logistic regression analysis was used which is one of the multi variables statistical techniques and aimed to apprise the relationships between the dependent variable and metric independent variables. As it's known, in a logistic regression analysis, the effects of independent variables on dependent variables are determined by using probability of the two levels of dependent variables. Logistic regression analysis was preferred instead

of other similar methods such as regression analysis and discriminant analysis because of its less stringent assumptions. A logistic regression analysis has two main methods naming single and multi variables for choosing variables. And these multi variable analysis has two sub methods which are stepwise and the best sub sets methods but the second one is rarely using in logistic regression analysis. The stepwise method has two methods in itself as forward selection and backward elimination (Lee/Koval, 1997:566). In this study, stepwise forward selection method was used for selecting variables.

In the logistic regression analysis, for determining the impact of independent variables on dependent variables, CAM, JIT, and TQM firms were coded with 1 and non-CAM, JIT, and TQM firms were coded with 0.

A. The effect of CAM Practices;

The logistic regression model which was constituted for determining the relationship between CAM practices and BSC measures usage. Hosmer-Lemeshow statistic was 7,945, -2 log likelihood statistic (LL) was 40,713 and significant level (p) was 0, 439 (p>,05) with 8 degrees of freedom. The results of goodness-of-fit test which are shown in Table 6 indicated that the logistic regression model was not a good fit. The Cox and Snell R^2 was found to be 14% in the second step and this statistic indicated that there was an approximately 14% relationship between the CAM practices and BSC measures usage. Also, Nagelkerke R^2 indicated that there was a 35.8% relationship between BSC measures usage and CAM. In other words, it showed that 35.8% of the variation in the dependent variable was explained by BSC measures usage in the model.

Table 6: Goodness-of-Fit Test of Model for CAM

Step						
1	48,035(a)	,085	,217	8,608	8	,376
2	40,713(b)	,140	,358	7,945	8	,439

a Estimation terminated at iteration number 6 because parameter estimates changed by less than ,001.

b Estimation terminated at iteration number 7 because parameter estimates changed by less than ,001.

Table 7 shows the results of the regression model which was constituted for determining the predictors of CAM practices. In the Table 7, "B" column shows the coefficients (called Beta Coefficients) associated with each predictor, "sig." column shows the significant levels and "Exp(B)" column shows the odds ratios. The *odds* ratio is defined as the probability of the outcome event occurring divided by the probability of the event not occurring and the odds ratio for a predictor tells the relative amount by which the odds of the outcome increase (odds ratio greater than 1.0) or decrease (odds ratio less than 1.0) when the value of the predictor value is increased by 1.0 units. In the model, the "B" coefficent was 0.824 for financial performance measures, p value was 0.009 and the model was statistically significant (p<,05). The odds ratio was 2.281 and indicated that one unit increase in financial performance measures increases 2.281 times the odds of CAM practices. Also, the beta coefficient for learning and growth measures was 1.428 and p value was 0.006 (p<,05). The odds ratio of learning and growth measures was 4.171 and indicated that one unit increase in learning and growth measures predictor variable increases 4.171 times the odds of CAM practices.

Table 7: Results of Logistic Regression for CAM

								Lower	**Upper**
Step 1(a)	Learning and growth measures	1,288	,446	8,357	1	,004	3,626	1,514	8,686
	Constant	3,264	,573	32,497	1	,000	26,149		
Step 2(b)	Financial performance measures	,824	,314	6,891	1	,009	2,281	1,232	4,221
	Learning and growth measures	1,428	,517	7,639	1	,006	4,171	1,515	11,483
	Constant	3,749	,727	26,592	1	,000	42,473		

a Variable(s) entered on step 1: Learning and growth measures.

b Variable(s) entered on step 2: Financial performance measures

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The success of the logistic regression can be assessed by looking at the classification table. Table 8 shows correct and incorrect estimates. The columns are the two predicted values of the dependent, while the rows are the two observed (actual) values of the dependent. According to this table, the 37.5% of firms which have non-CAM practices, 99.1% of firms which have CAM practices were appointed correctly. With the analysis made the correct classification rate was found as 94,9%.

Table 8: Classification Table of Logistic Regression for CAM

		Predicted		**Percentage Correct**
		CAM		
		0	**1**	
Observed **CAM**	**0**	3	5	37,5
	1	1	109	99,1
Overall Percentage				94,9

The cut value is ,500

B. The effect of JIT Practices;

The logistic regression model which was constituted for determining the relationship between JIT practices and BSC's sub dimensions. Hosmer-Lemeshow statistic was 17.762 and marginal significant level was 0.023 (p>,05) with 8 degrees of freedom. The results of goodness-of-fit test which are shown in Table 9 indicated that the logistic regression model was a good fit. When the Cox and Snell R^2 indicated that 15.5% of the variation in JIT practice level was explained by financial performance measures, customer performance measures, internal business processes measures. Also, Nagelkerke R^2 indicated that 24.6% of the variation in JIT practice level was explained by these three predictor variables in the model.

Table 9: Goodness-of-Fit Test of Model for JIT

Step						
1	106,498(a)	,078	,124	10,466	8	,234
2	100,234(a)	,126	,200	24,788	8	,002
3	96,332(a)	,155	,246	17,762	8	,023

a Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.

Table 10 shows the results of the regression model which was constituted for determining the predictors of JIT practices. The table's left column shows that stepwise model-building process included three steps. In the first step, a constant as well as internal business processes measures predictor variable was entered into the model, at the second step, customer performance measures predictor variable was added to the model and at the third step, financial performance measures variable was added to the model. The beta coefficient (B) of internal business processes measures was 0.820 and p value was 0,004 (p<,05). The odds ratio of internal business processes measures predictor was 2,270 and this statistic indicated that one unit increase in internal business processes measures increases 2,270 times the odds of JIT practices. However, The beta coefficient for customer performance measures was 0,610 and p value was 0,016 (p<0,05). The odds ratio of customer performance measures was 1,841 and indicated that one unit increase in this independent variable increases 1,841 times the odds of JIT practices. The beta coefficient for financial performance measures was 0,440, p value=0,052 was found and it was not statistically significant at 0,05 level (p>,05).

Table 10: Results of Logistic Regression for JIT Practices.

								Lower	**Upper**
Step 1(a)	Internal business processes measures	,782	,271	8,294	1	,004	2,185	1,284	3,719
	Constant	1,513	,256	34,985	1	,000	4,539		
Step 2(b)	Internal business processes measures	,775	,275	7,958	1	,005	2,171	1,267	3,720
	Customer performance measures	,595	,249	5,689	1	,017	1,813	1,112	2,957
	Constant	1,636	,279	34,395	1	,000	5,133		
Step 3(c)	Internal business processes measures	,820	,284	8,344	1	,004	2,270	1,302	3,960
	Customer performance measures	,610	,254	5,786	1	,016	1,841	1,120	3,028
	Financial performance measures	,440	,226	3,780	1	,052	1,552	,996	2,418
	Constant	1,723	,297	33,758	1	,000	5,604		

In the classification which was made according to JIT practices; the 21.7% of firms which have non-JIT practices, 100% of firms which have JIT practices were appointed correctly. With the analysis made the correct classification rate was found as 84,6%.

Table 11: Classification Table of Logistic Regression for JIT practices

		Predicted		Percentage Correct
		JIT		
		0	1	
Observed JIT	0	5	18	21,7
	1	0	94	100,0
Overall Percentage				84,6

The cut value is ,500

C. The effect of TQM;

Table 12 shows the goodness-of-fit test of the logistic regression model which was constituted for determining the effect of predictors on TQM practice levels of firms. As seen in Table 12, Hosmer-Lemeshow statistic was 4,978 and marginal significant level was 0,760 (p>,05) with 8 degrees of freedom. These results indicated that the logistic regression model was not a good fit. Cox and Snell R^2 indicated that 9.7% of the variation in TQM practice level was explained by financial performance measures, learning and growth measures. Also, Nagelkerke R^2 indicated that 18,4% of the variation in TQM practice level was explained by by these two predictor variables in the model.

Tablo 12: Goodness-of-Fit Test of Model for TQM Practices

Step						
1	84,691(a)	,048	,092	6,756	8	,563
2	78,355(a)	,097	,184	4,978	8	,760

a Estimation terminated at iteration number 5 because parameter estimates changed by less than ,001.

Results of the logistic regression model for TQM practices are shown in Table 13. As seen in Table 13, logistic regression analysis had two steps. In the

first step, financial performance measures predictor variable was entered into the model, and in the second step, learning and growth measures predictor variable was added to the model. The beta coefficient (B) of financial performance measures was 0,587 and p value was 0,016 (p<,05). The odds ratio of financial performance measures predictor was 1,799 and indicated that one unit increase in financial performance measures increases 1,799 times the odds of TQM practices. The beta coefficient for learning and growth measures predictor was 0,748 and p value was 0,016 (p<,05). The odds ratio of learning and growth measures predictor was 2,113 and indicated that one unit increase in this independent variable increases 2,113 times the odds of TQM practices, controlling for other variables in the model.

Table 13: Results of Logistic Regression for TQM practices

								Lower	**Upper**
Step 1(a)	Financial performance measures	,600	,241	6,199	1	,013	1,822	1,136	2,922
	Constant	2,099	,306	47,175	1	,000	8,155		
Step 2(b)	Financial performance measures	,587	,244	5,781	1	,016	1,799	1,115	2,904
	Learning and growth measures	,748	,309	5,856	1	,016	2,113	1,153	3,873
	Constant	2,287	,349	42,927	1	,000	9,845		

In the classification which was made according to TQM practices; the 20% of firms which have non-TQM practices, 99.1% of firms which have TQM practices were appointed correctly. With the analysis made the correct classification rate was found as 89,3%.

Table 14: Classification Table of Logistic Regression for TQM practices

		Predicted		Percentage Correct
		TQM		
		0	1	
Observed TQM	0	3	12	20,0
	1	1	105	99,1
Overall Percentage				89,3

The cut value is ,500

In conclusion, the logistic regression analysis indicated that there was a significant relationship between level of CAM practices and predictors of financial performance measures and learning and growth measures. There was a significant relationship between level of JIT practices and the predictors of financial performance measures, customer performance measures, internal business processes measures. However, there was a significant relationship between level of TQM practices and the predictors of financial performance measures and learning and growth measures.

4. DISCUSSION AND RESULT

Today, in order to get a competitive advantage, firms not only change their rigid strategic priorities such as low cost, product quality, speed and flexibility, but also mobilized the new technology and opinions towards these facts. CAM, JIT and TQM are the products of these searches. All of these instruments and approaches altered the perception towards performance measurement system (Daniel/Reitsperger, 1991: 601-618) and thus, performance measurement system has begun to be evaluated multidimensionally from the view of several functions of firms.

This study intends to reveal the theoretical relationship between BSC and production and management techniques empirically through the contingency approach. In this connection, the study confirmed that the three elements that define the new manufacturing environment are characteristic variables that are contingent upon performance measurement, and as a result, their degree of

effectiveness differs. These results support the contingency approach because the effects of variables on performance measurement show a difference.

According to the results, there is a noticeable positive relationship between firm's multiple performance measures usage and the organizations prefer a CAM model. Therefore, the results support the idea that an organizational strategy, which regards the multiple performance measurement system, need to follow the changes in manufacture environments like CAM.

Also, it contends that there is a significant positive relationship between the management techniques (such as JIT and TQM) and the usage of BSC. In this connection, it's conceivable that the firms using these management techniques emphasize multiple performance measures more than the others.

To reveal the relationship, a comprehensive analysis is carried out on CAM, JIT and TQM by using the logistic regression analysis. In respect of this, multiple performance measurement can appear in both two firms (use or not use CAM, JIT, TQM) but it can be possible in various degrees. These results are sum up in following paragraphs.

In the first logistic regression model which was constituted for determining the effect of CAM practice on the use of BSC, financial performance measures and learning and growth measures were found to be significant predictors. Accordingly, financial performance measure usage level is 2.281 times higher in firms with CAM practice than the ones with non-CAM practice. Also, use of learning and growth measures is 4,171 times higher in firms having CAM practice rather than ones having non-CAM practice. The overall correct classification percentage of this logistic regression model was found to be 94,9%.

In the second logistic regression model which was constituted for determining the effect of JIT on the use of BSC, internal business process measures, customer performance measures and financial performance measures are more determining, which are seen here. As to this, firms with JIT practice are compared to the ones with non-JIT practice has shown that use of internal business process measures is 2,27 times, customer performance measures is 1,841 times higher. With the analysis, the correct classification rate was found as 84,6%.

In the last logistic regression model which was constituted for determining the effect of TQM apply on the use of BSC, financial performance measures and learning and growth measures are seen to be effective on firms that apply TQM. As to this model, firms with TQM apply according to firms with non-TQM firms has indicated that the usage of financial performance measures is 1.799 times and the usage of learning and growth measures is 2.113

times higher. With the analysis, the correct classification rate was found as 89,3%.

Since Turkey is a developing country that simultaneously experiences the global technological and competitive effects with developed countries, the practical importance and necessity of the studies related to performance evaluation can be seen more clearly. This study contributes to the local academic accumulation of knowledge related to this subject. On the other hand, when the aforementioned study account for only the CAM, JIT and TQM, it is clear that it is necessary to examine the subject using variables such as competitive factors, organizational culture and business structure.

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