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Research Article

Measuring the Performance of Retailer Firms Listed in BIST under the Balanced Scorecard Perspective by Using Interval Valued Pythagorean Fuzzy AHP Based Pythagorean Fuzzy TODIM Methodology

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ABSTRACT

The philosophy behind the Balanced Scorecard is the necessity for an operator to transform non-financial criteria into data sources for the management information system, as well as financial criteria for all governance levels. The Balanced Scorecard introduces solutions to the problems that arise from the failures encountered in strategic management and the inadequacy of traditional performance management systems that lag behind the information age in today's intensely competitive environment, which is pushing businesses more and more. In this study the performance of 12 retailer firms listed in BIST are measured under the balanced scorecard (BSC) perspective by handling 4 main criteria (financial, customer, internal business process and learning & growth perspectives). Pythagorean fuzzy sets (PFS) are considered in order to better represent experts' judgments under inconsistent and indeterminate environment. Following that TODIM methodology, that analyzes decision makers' psychological behaviors under risk, is used to rank the firms. While economic loyalty sub criterion was found as the most important one, participation in management was acquired as the least important one after applying interval valued Pythagorean fuzzy AHP. Finally, Firm F was ranked as the most successful firm according to decision makers under balanced scorecard performance criteria.

Keywords: Balanced Scorecard, Pythagorean Fuzzy Sets, Pythagorean Fuzzy AHP, Pythagorean Fuzzy TODIM

1. Introduction

As the Fourth Industrial Revolution experienced today, there are radical changes in the business world as well as in all areas of life. The business environment, tailored to traditional circumstances, is no longer able to respond to needs. Balanced Scorecard (BSC) supports the achievement of objectives by developing effective solutions to the problem of the inadequacy of traditional performance measurement systems and the strategic failures faced by information society enterprises. Providing a framework in which the vision, mission and strategy of the business are transformed into performance measures covering non-financial issues, BSC aims to solve the problems experienced in performance evaluation (Güner, 2008, p.250).

Until the early 1990s, many academics were only interested in problems with traditional financial performance measures (Johnson & Kaplan, 1987; Lynch & Cross, 1991). Prior to Kaplan and Norton, academics criticized measures that encouraged managers to focus on short-term financial performance that ignores long-term expectations (for example, Bromwich & amp; Bhimani, 1989; McNair et al., 1990). These and many other academics (such as Lynch & Cross, 1991) have suggested that in addition to financial measures of performance, non-financial measures such as on-time delivery, reduced process costs, quality and cycle times will benefit the long run. Connecting performance measures to strategy is not a unique idea for a balanced scorecard. McNair et al. (1990) has developed a performance pyramid that combines financial and non-financial measures. Grady (1991) emphasized that an operator's strategic objectives should be associated with critical success factors and critical actions.

The emergence of BSC method is based on the work of 'measuring performance in future organizations', which started in 1990 and lasted for a year, focusing on how performance criteria can be used in a wider range of ways in profitable businesses (Gooijer, 2000, p.306). Leader of the study is David Norton and academic adviser is Robert Kaplan. Representatives of many companies operating in different sectors, such as production, service, advanced technology and heavy industry, gathered together once a month to develop a new performance measurement method (Calabro, 2001, p.73).

2. Balanced Scorecard

Kaplan and Norton (1992) have developed the idea of combining financial and non-financial (customer, in-house functions, innovation and learning) perspectives into a single performance metering card model with the name of the Balanced Scorecard by leveraging the performance of the electronic circuit company (ECC). In Kaplan and Norton's subsequent publications, they have removed the word "Business" from a model commonly known as Balanced Scorecard. After this first work, they developed the idea of balanced scorecard with many publications. In the Balanced Scorecard: Strategy Action Conversion book, they reclassified two of the four perspectives in the article published in 1992. The internal perspective is called internal business processes, emphasizing the importance of innovation, while innovation and learning perspective has been renamed learning and growth by removing the innovation element and adding the element of growth (Kaplan & Norton, 1996, p.9). Balanced

Scorecard published in 1996 was different than the one published in 1992 because it saw output measurements and outputs connected with cause-and-effect relationships that make the performance measurement system a proactive control system as a performance-guiding tool. Kaplan and Norton (1996, p.31) addressed this causal and consequential relationship in four stages: organizational learning and growth measures, internal business process measures, customer perspective measures, and financial measures.

In their next work, Kaplan and Norton (2008a, 2008b), linkage between scorecard metrics and an organizational strategy map emerges. They demonstrated how they can establish a strong link between the strategies of their organizations and their activities, so that their daily operational activities will support organizational strategic objectives. Table 1 shows the historical development of the balanced scorecard (Hoque, 2014, p.36).

Year/paper Type	Publication Title	Key Areas Covered
1992/Article	The balanced scorecard-measures that drive performance	Introduction of balanced scorecard as a foundation for development
		Balanced scorecard is a superior performance measurement that uses both financial and non-financial measures
		Identification of the four perspectives: financial; customer; internal business; innovation and learning
		Balanced scorecard is forward-looking (long-term performance)
1993/Article	Putting the balanced scorecard to work	Balanced scorecard is not only a measurement exercise, it is also a management system to motivate breakthrough improvement
		Balanced scorecard has greatest impact when used to drive a change process
		Identification that transparency is critical to a successful balanced scorecard
		Measures on balanced scorecard must be specifically designed to fit firm's mission, strategy, technology, and culture
1996/Book	The balanced scorecard: Translating strategy into action	Balanced scorecard has evolved from a measurement system to a strategic management system
		Identification of four major steps in successful balanced scorecard implementation
		Reclassification of "internal business process" and "learning and growth", shifting innovation to internal business processes and adding growth element to employee learning
		Measures are linked to each other in a causal relationship, unlike before, linked to strategy and vision
2001/Book	The strategy-focused organization: How balanced scorecard companies thrive in the new competitive environment	Translating the strategy to operational terms: building strategy maps
		Aligning the organization to create synergies: creating business unit synergy
		Making strategy everyone's everyday job: creating strategic awareness, defining personal and team objectives, the balanced paycheck
		Making strategy a continual process: planning and budgeting, feedback and learning
		Mobilizing change through executive leadership
2004/Book	Strategy maps: Converting intangible assets into tangible outcomes	Visually map strategy
		A visual cause-and-effect explanation of what's working and what's not, in a way that everyone in the company can understand
		Helps get the entire organization involved in strategy
2006/Book	Alignment: Using the balanced scorecard to create corporate synergies	Alignment: a source of economic value
		Corporate strategy and structure
		Aligning financial and customer strategies
		Aligning internal process and learning and growth strategies: integrated strategic themes
		Aligning boards and investors
		Aligning external partners
		Managing the alignment process
		Total strategic alignment

Table 1. Development of Balanced Scorecard concept by Kaplan and Norton (Hoque, Z.,2014).

The development of the balanced scorecard summarized in Table 1 shows the diversity of ideas in its philosophy. Recently, a broader strategy map approach has been adopted to measure, monitor and manage an operator's performance and operations to ensure that today's businesses can continue to operate around the rapidly changing business environment. This change in the original conceptual framework was influenced by Kaplan and Norton's own research on balanced scorecards and other interpretations (eg, Nørreklit, 2000, 2003). According to Kaplan, 'Recent developments are about much more than a balanced score card. Developments Balanced Scorecard Model is embodied as an element in a comprehensive management system that combines strategies and operations.' In the series on balanced scorecards, Kaplan and Norton argue that the last balanced scorecard model provides a more comprehensive and more holistic view of the organization and that the model can be used according to any perspective chosen for a particular application (Hoque, 2014, p.36).

It expresses the vision and strategy of BSC operator in four perspectives consisting of financial and non-financial criteria (Pineno, 2002, p.69). These are perspectives of learning and growth through financial perspective, customer perspective, internal business process perspective. Within these four perspectives, there are measures that provide effective performance measurement in operation.

Since BSC has different measures, it prevents the development of an area and the consequences of improvements to be noticed in another area. For example, even though reducing the investments increases profitability in the short term, it has many negative consequences in the middle and long term (Storey, 2002, p.325). BSC demonstrates how managers can assess all the important criteria and achieve success in one area by spending or making sacrifices in different areas. Two of the most fundamental characteristics of BSC are that the collectors and managers compel all performance measures to be taken into consideration in a single management report with the information to be obtained from many different reports. Lopes (1996, p.7), which emphasizes the broader nature of BSC, sets an important advantage to allow the performance to be assessed at the same time in various areas by using criteria complementary to financial criteria that inform the future of the business. In addition, BSC provides important advantages in terms of clarifying the processes, determining the problems within the enterprise and resolving the urgent needs by strengthening internal communication (Ritter, 2003, p.59). It removes the obstacles for executives to transfer their strategic goals to employees, especially in large enterprises (Davis, 1996, p.14). Table 2 shows the balanced scorecard of a sample business (Argüden, 2000, p.43).

Financial Perspective		**Customer Perspective**	
Objectives	***Measurements***	***Objectives***	***Measurements***
To maintain the entity's assets	Cash flow	New products	Percentage of sales of new products Percentage of sales of registered products
To be successful	Quarterly increases in quarterly sales and operating income	Responsive service	On-time delivery (defined by customer)
To increase the fortune of the business	Increase in market share and resource yield	Be a preferred supplier	Company's share in key customers' purchases Sort by key customers
		Customer partnership	Number of collaborative works in design
Internal Business Process Perspective		**Learning and Growth**	
Objectives	***Measurements***	***Objectives***	***Measurements***
Technology capacity	Production geometry in comparison with opponents	Leadership in technology	Time to develop next generation of technology
Excellence in production	Cycle time, Unit cost Income	Learning in production	Process maturation period
Productivity in design	Silicone productivity Engineering efficiency	Product focus	Percentage of products that make up 80% of sales
Offering new products	Comparing new product offer plan with actual case	Time to market	Provide new products comparatively with opponents

Table 2. Example of a Balanced Scorecard Business (Argüden, Y., Sağdıç, E., Kaplan, R. S. ve Norton, D. P., 2000)

2.1. Internal Business Process Perspective

Internal business perspective focuses on the activities that an organization is committed to satisfying its customers. For example, in a manufacturing operation, the assembly of a product is an internal business process (Giannopoulos, 2013, p.5). In this perspective, management determines what processes the business needs to develop or improve. These processes ensure that the operator attracts or retains shares in the target market, and satisfies shareholders' financial expectations. For this reason, measures such as efficiency, cycle time, quality, cost, response time, new product presentation, etc., which are involved in the process in question, focus on processes that are most effective in achieving customer satisfaction and financial goals. (Gentia, 1998, p.6). Internal business process perspective reflects the difference between BSC and traditional systems in performance measurement. Conventional performance measurement emphasizes correcting the criteria based on cost, quality and time of existing business processes. BSC allows the entity to identify new methods and procedures that must be applied in a flawless manner to achieve their goals for customer satisfaction and financial objectives. Another issue that differs from the traditional methods of balancing the score card is that innovation is included in internal business processes. Businesses can design products and services that address the existing and potential needs of customers with measures that take place through innovation. This perspective brings together both long-term innovation processes and short-term operational processes (Ölçer, 2005, p.95).

2.2. Customer Perspective

Customer perspective focuses on the views of customers and how the business can be viewed by customers. Especially in today's competitive business environment, many businesses give priority to customer satisfaction and see it as an important performance measure in achieving success (Anderson ve Sullivan, 1994). Customers generally have four main concerns about the product or service offered by a business: time, quality, service performance and cost. For this reason, it is necessary to organize

the business objectives according to these four factors and to convert these goals into specific criteria (Giannopoulos, 2013, p.5).

The basic outcome measures of this perspective consist of measures such as customer loyalty, customer satisfaction, acquisition of new customers, customer profitability and achieving the intended market share. It also needs to cover factors related to customer value proposals that the enterprise will try to bring to market segments that it intends. Customer value proposals represent the qualities offered by the producer's enterprise to create commitment and satisfaction in the target customer segment with goods and services. Although there are different value propositions for different sectors and different market segments, common approaches in BSC work in many enterprises can be grouped into three groups as product and service characteristics (functionality, price, quality), customer relations (such as delivery time) and image (advertising, slogan, reliability) (Ölçer, 2005, p.95).

2.3. Learning and Growth Perspectives

The learning and growth perspective is concerned with the regulation of long-term institutional learning and development goals and criteria. The aims of this perspective provide the infrastructure needed to realize the high goals and improvements identified in other perspectives. Other perspectives in BSC will reveal the difference between the current performance of employees, processes and methods and the performance required for the development of the business. To eliminate this disparity, businesses have to bring new skills to their employees, improve their information technology skills, and improve their in-house methods and programs. These objectives are explained in the context of learning and growth in terms of the skills of the employees, the competence of the information system and motivation, authorization and connection (adaptation). In this context, after determining criteria such as satisfaction, productivity and continuity with employees, it is necessary to determine activities such as learning and development perspective to acquire new talents, increase capacity of information systems, motivation, authorization and adaptation (Ölçer, 2005, p.95).

2.4. Financial Perspective

The financial perspective is the last perspective of the BSC model. This perspective reflects the financial appearance of an entity against its shareholders and whether it contributes to the improvement in the financial success of the entity's operations, practices and strategy. Together with the other three perspectives of BSC model, benchmarks generally focus on financial goals related to growth, profitability and shareholder value. Businesses should use not only financial data but also metrics that emphasize strategy models and the entire strategy of the business.

BSC benefits from data that summarizes the current situation and economic consequences of past activities. In this context, it contributes to the determination of financial objectives for different periods in order to support the growth and sustainability of the business. Since financial objectives are the focal point for the purposes and criteria of other perspectives in BSC, the goals and criteria of other perspectives must be made part of the cause-and-effect relationships that will lead to improved financial performance. Financial performance measures determine whether the operator contributes to development by assessing its strategy

implementation (Dilanthi vd., 2000, p.71). Examples include income growth, profitability of the capital, profitability of the investment, economic value added, cost efficiency, and stockmarket financial measures.

These four perspectives have been determined to be sufficient for many different industries and businesses. However, these four perspectives should be regarded as a template. BSC model predicts that the number of perspectives will change according to the situation of the businesses. According to this, there may be only two or three perspectives to use from the four perspectives by businesses, and perspectives over these four can be used by businesses according to the characteristics of the operating industry and the business strategy. However, these four perspectives are usually optimal for businesses. Less will not provide the necessary breadth, and more will have administrative difficulties (Ölçer, 2005, p.96). A sample set of success criteria in Table 3 and measurement methods of success measures in Table 4 (Baynal ve Karasakal, 2008, p.4).

Perspective			**Criteria**		
Internal Business Process	Inventory usage rate	Efforts to develop new products and services	Minimizing operational problems	Energy expenditure sales ratio	
Customer	Customer loyalty	Customer satisfaction rate	Making full product diversity		
Learning and Growth	Employee training	Employee happiness and satisfaction	Persistence of employees	Employee self-improvement and career opportunities	
Financial	Increasing productivity profitability	Business growth	Increasing productivity	Lowering costs	Shortening cash return period

Table 3. Sample Criteria by Perspective (Baynal, K., ve Karasakal, O., 2008)

Financial Perspective (F)	**Customer Perspective (C)**
F1. Sales return	C1. Customer satisfaction
F2. Cash cycle period	C2. Customer loyalty
F3. Stock turnover	C3. Recursive sales
F4. Net profit margin	C4. Professionalism based customer relationship management
F5. Accounts receivable turnover rate	C5. Customer returns
F6. Return of investments	C6. Acquired/lost customers
F7. Profit/turnover	
F8. Profit/working capital	
F9. Cost of capital	
Internal Business Process Perspective (I)	**Learning and Growth (G)**
I1. Control of production costs	G1. New customer acquisition trend
I2. Team work and cooperation between departments	G2. Market share
I3. Participation in management	G3. Development of employees' business knowledge
I4. Human resource management and employee motivation	G4. Increasing the rate of productivity and capacity usage
I5. Product and quality management	G5. Usage of opportunities and durability against threats
I6. New product and service development efforts	G6. Strategic thinking and ability to predict the future
I7. Minimizing operational issues	G7. Problem solving, creativity and inventiveness
	G8. Technology utilization and research & development

Table 4. Measuring Methods of Criteria of a Sample Business (Baynal, K., ve Karasakal, O., 2008)

3. Method

3.1. Pythagorean Fuzzy Sets

Pythagorean fuzzy sets (PFS) incorporating Intuitionistic fuzzy sets (IFS) is developed by Yager (2013) in order to better represent vague, uncertain and imprecise environment. PFS can handle indeterminate and uncertain judgments of human beings more efficiently. PFS can be expressed such as:

Let X be a non-empty fixed set. A PFS P is a mathematical object having the form as below:

$$P:\{<x,\mu_P(x),\nu_P(x)>;x\in X\} \tag{1}$$

Where the function $\mu_P(x):x\to[0,1]$ denotes the degree of the membership and $\nu_P(x):x\to[0,1]$ denotes the degree of non-membership of the element $x\in X$ to P respectively, for every $x\in X$,

$$0\le(\mu_P(x))^2+(\nu_P(x))^2\le 1 \tag{2}$$

PFS is characterized by membership and non-membership degrees whose sum of squares is less than or equal to 1.

In addition the hesitant degree of is calculated as follows:

$$\pi_P(x)=\sqrt{1-\mu_P(x)^2-\nu_P(x)^2} \tag{3}$$

Let $A_1=P(\mu_{A_1},\nu_{A_1})$ and $A_2=P(\mu_{A_2},\nu_{A_2})$ be two Pythagorean fuzzy number (PFNs) and λ>0, then the operations on these two PFNs are defined as below:

$$A_1\oplus A_2=P\left(\sqrt{\mu_{A_1}+\mu_{A_2}-\mu_{A_1}\mu_{A_2}},\nu_{A_1}\nu_{A_2}\right) \tag{4}$$

$$A_1\otimes A_2=P\left(\mu_{A_1}\mu_{A_2},\sqrt{\nu_{A_1}+\nu_{A_2}-\nu_{A_1}\nu_{A_2}}\right) \tag{5}$$

$$\lambda A_1=\left(\sqrt{1-\left(1-\mu_{A_1}^2\right)^{\lambda}},\nu_1^{\lambda}\right) \tag{6}$$

$$A_1^{\lambda}=\left(\mu_{A_1}^{\lambda},\sqrt{1-\left(1-\nu_{A_1}^2\right)^{\lambda}}\right) \tag{7}$$

Let $B=P(\mu_B,\nu_B)$ be a PFN, then score and accuracy functions of B is computed as follows:

$$s(B)=(\mu_B)^2-(\nu_B)^2 \tag{8}$$

$$h(B)=(\mu_B)^2+(\nu_B)^2 \tag{9}$$

The larger score and accuracy functions of $s(B)$ and $h(B)$, the better and higher accuracy of PFN B.

The Euclidean distance of two PFNs such as $C_1=P(\mu_{C_1},\nu_{C_1})$ and $C_2=P(\mu_{C_2},\nu_{C_2})$ can be obtained as below:

$$d(C_1,C_2)=\sqrt{\frac{1}{2}\left[\left((\mu_{C_1})^2-(\mu_{C_2})^2\right)^2+\left((\nu_{C_1})^2-(\nu_{C_2})^2\right)^2+\left((\pi_{C_1})^2-(\pi_{C_2})^2\right)^2\right]} \tag{10}$$

3.2. Interval- Valued Pythagorean Fuzzy AHP

Criteria and alternatives are evaluated by taking weighting scale into the account under pythagorean information shown as Table 1. Steps of interval-valued pythagorean fuzzy AHP are given as follows (İlbahar, Karaşan, Çebi & Kahraman, 2018, p.127):

1- Compromised pairwise comparison matrix $E = (e_{ij})_{kxk}$ is obtained by taking experts' opinions into the account via weighting scale seen as Table 5.

Linguistic terms	Interval valued pythagorean fuzzy numbers			
	μ_L	μ_U	ν_L	ν_U
Certainly low importance	0	0	0.9	1
Very low importance	0.1	0.2	0.8	0.9
Low importance	0.2	0.35	0.65	0.8
Below average importance	0.35	0.45	0.55	0.65
Average importance	0.45	0.55	0.45	0.55
Above average importance	0.55	0.65	0.35	0.45
High importance	0.65	0.8	0.2	0.35
Very high importance	0.8	0.9	0.1	0.2
Certainly high importance	0.9	1	0	0
Exactly equal	0.197	0.197	0.197	0.197

Table 5. Weighting scale used for evaluating criteria and alternatives under pythagorean information

2-Difference matrix D=〚(d_ij)〛_kxk is constructed by considering lower and upper values of the membership and non-membership functions as Eqs. (11) and (12):

$$d_{ijL} = \mu_{ijL}^2 - v_{ijU}^2 \quad (11)$$

$$d_{ijU} = \mu_{ijU}^2 - v_{ijL}^2 \quad (12)$$

3- Interval multiplicative matrix P=〚(p_ij)〛_kxk is obtained by using Eqs. (13) and (14):

$$p_{ijL} = \sqrt{1000^{d_L}} \quad (13)$$

$$p_{ijU} = \sqrt{1000^{d_U}} \quad (14)$$

4- Determinacy value τ_ij of the elements of compromised pairwise comparison matrix e_ij is computed according to Eq. (15):

$$\tau_{ij} = 1 - \left(\mu_{ijU}^2 - \mu_{ijL}^2\right) - \left(v_{ijU}^2 - v_{ijL}^2\right) \quad (15)$$

5- The matrix of weights Z=〚(z_ij)〛_kxk is constructed by multiplying determinacy degress with P=〚(p_ij)〛_kxk matrix as Eq. (16):

$$z_{ij} = \left(\frac{p_{ijL}+p_{ijU}}{2}\right)\tau_{ij} \quad (16)$$

6- Finally normalized priority weights are calculated according to Eq. (17):

$$w_i = \frac{\sum_{j=1}^{k} z_{ij}}{\sum_{i=1}^{k}\sum_{j=1}^{k} z_{ij}} \quad (17)$$

3.3. TODIM

TODIM (an acronym in Portuguese for Interactive Multi- Criteria Decision Making) developed by Gomes and Lima (1992) for analyzing decision makers' psychological behaviours under risk. This theory is based on the prospect theory proposed by

Kahneman and Tversky (1979) by considering the dominance of each alternative over others with the usage of function of multi-criteria values (Ren, Xu & Gou, 2016, pp. 246-247).

Shape of the function of multi-criteria values resembles gain/loss function of prospect theory. The function of multi-criteria values is constructed under the condition of reproducing the gain/loss function of prospect theory (Gomes & Rangel, 2009, p.205). TODIM method considers the projection of differences between two alternative values according to reference criterion under pairwise comparisons. As a noncompensatory method, while verbal value judgments, fuzzy evaluations and interdependence relationships between alternatives are possible, tradeoffs are not allowed (Gomes & Rangel, 2009, p.205).

Let k alternatives and l criteria (qualitative or quantitative) by handling one of them as a reference criterion. Then evaluation values are acquired under the contribution of each alternative to objective with related criterion. These values composed the evaluation matrix where all values are numerical. Then normalization process is executed for each criterion in order to construct the normalized alternatives scores against criteria matrix where all values are between 0 and 1 (Gomes & Rangel, 2009, pp.205-206).

Weights of the criteria are determined by decision makers and normalized too. So a reference criterion d having the highest importance value is selected and normalization process is executed by calculating values. is the weight of criterion c divided by the weight of reference criterion d. All pairs of differences between performance measurements are translated into reference criterion via considering values. As a result the measurement of dominance of each alternative over another each alternative can be written by sum of relative gains and losses as below:

$$\delta\left(A_i,A_j\right)=\sum_{c=1}^{m}\Phi_c\left(A_i,A_j\right),\forall\left(i,j\right) \tag{18}$$

According to Eq (18), $\delta\left(A_i,A_j\right)$ describe the measurement of dominance of alternative A_i over alternative A_j under m criteria c=1,...,m.

$$\Phi_c\left(A_i,A_j\right)=\begin{cases}\sqrt{\dfrac{w_{dc}\left(P_{ic}-P_{jc}\right)}{\sum_{c=1}^{n}w_{dc}}} & if\left(P_{ic}-P_{jc}\right)>0\\ 0 & if\left(P_{ic}-P_{jc}\right)=0\\ -\dfrac{1}{\theta}\sqrt{\dfrac{\left(\sum_{c=1}^{m}w_{dc}\right)\left(P_{jc}-P_{ic}\right)}{w_{dc}}} & if\left(P_{ic}-P_{jc}\right)<0\end{cases} \tag{19-20-21}$$

According to Eqs (19-21). P_{ic} and P_{jc} represent the performances of the alternatives A_i and A_j related with c ; θ can be considered as the attenuation factor of the losses. Different choices of θ lead to different shapes of the prospect theoretical value function in negative quadrant.

Expression of $\Phi_c(A_i,A_j)$ denote the contribution of criterion c to function $\delta(A_i,A_j)$ when comparing alternative i with j. While the value of $P_{ic}-P_{jc}$ is positive, it reveals gain for the function of $\delta(A_i,A_j)$ and $\Phi_c(A_i,A_j)$ is represented by Eq (19). From other side the negative value of $P_{ic}-P_{jc}$ lead loss fort he function of $\delta(A_i,A_j)$ and $\Phi_c(A_i,A_j)$ is represented by Eq (21). Additionally if $P_{ic}-P_{jc}$ is nil, the value zero is assigned to $\Phi_c(A_i,A_j)$ by using Eq (20). The function of $\Phi_c(A_i,A_j)$ explain aversion and propensity to risk by allowing adjustment of the data of problem to the value function of prospect theory (Gomes & Rangel, 2009, pp.205-206).

Final dominance matrix of general element $\delta(A_i,A_j)$ is acquired by calculating the sum of elements of the diverse partial matrices. The overall value of alternative i (ξ_i) computed by normalizing the corresponding dominance measurements shown as follows:

$$\xi_i=\frac{\sum_{j=1}^{m}\delta(A_i,A_j)-\min\sum_{j=1}^{m}\delta(A_i,A_j)}{\max\sum_{j=1}^{m}\delta(A_i,A_j)-\min\sum_{j=1}^{m}\delta(A_i,A_j)} \tag{22}$$

Global measures computed according to Eq (22) provide complete rank ordering of all alternatives. Sensitivity analysis can be executed to confirm stability of the results and changed according to θ, criteria weights, choice of reference criteria and performance evaluations.

3.4. Pythagorean Fuzzy TODIM

Pythagorean fuzzy TODIM aims to analyze the set of alternatives by considering the collection of criteria under PFN based evaluation values. Let $M=\{M_i|i\in k\}$ be a set of alternatives and $N=\{N_j|j\in L\}$ be a set of criteria. Weigh vector of the criteria can be shown as $w=(w_1,w_2,\dots,w_l)^T$ where $w_j\in\{0,1\}$ $(j=1,2,\dots,l)$ and $\sum_{j=1}^{l}w_j=1$. The evaluation value related with alternative M_i and criterion N_j is represented as PFN $f_{ij}=P(\mu_{ij},v_{ij})$, where μ_{ij} indicates the degree that alternative M_i satisfies criterion N_j, and v_{ij} shows the degree that alternative M_i dissatisfies criterion N_j. As a result pythagorean fuzzy decision matrix $F=(f_{ij})_{kxl}$ is constructed as below:

$$F=(f_{ij})_{kxl}=\begin{pmatrix}P(\mu_{11},v_{11}) & P(\mu_{12},v_{12}) & \dots & P(\mu_{1l},v_{1l})\\ P(\mu_{21},v_{21}) & P(\mu_{22},v_{22}) & \dots & P(\mu_{2l},v_{2l})\\ \vdots & \vdots & & \vdots\ \ \vdots\\ P(\mu_{k1}v_{k1}) & P(\mu_{k2},v_{k2}) & \dots & P(\mu_{kl},v_{kl})\end{pmatrix} \tag{23}$$

First step of the prospect theory based on pythagorean fuzzy TODIM, considering decision makers' psychological behaviors under risk, is to normalize pythagorean fuzzy decision matrix according to benefit and cost criteria. Cost criteria can be converted into benefit ones to make all criteria compatible via Eq. (24):

$$g_{ij}=\begin{cases}f_{ij}, & for\ benefit\ criterion\ N_j\\ (f_{ij})^c, & for\ cost\ criterion\ \ N_j\end{cases} \tag{24}$$

According to Eq.(24) $(f_{ij})^c=P(v_{ij},\mu_{ij})$ represents the complement of f_{ij}. Then the normalized pythagorean fuzzy decision matrix $G=(g_{ij})_{kxl}$ can be acquired. Following to that the relative weight of each criterion N_j is computed as below:

$$w_{jr} = \frac{w_j}{w_r} \quad for \;\; j,r = 1,2,\dots,l \tag{25}$$

where $w_j$indicates the weight of criterion N_j and reference criterion can be represented by $w_r = max\{w_j | j = 1,2,\dots,l\}$ and $0 \le w_{jr} \le 1$.

After that dominance degree of alternative M_i over each alternative M_s in terms of criterion N_j can be founded as follows:

$$\varphi_j(M_i, M_s) = \begin{cases} \sqrt{w_{jr} d(g_{ij}, g_{sj}) / \sum_{j=1}^{l} w_{jr}} & if \quad g_{ij} > g_{sj} \quad (26) \\ 0 & if \;\; g_{ij} = g_{sj} \quad (27) \\ -\frac{1}{\theta}\sqrt{\frac{\left(\sum_{j=1}^{l} w_{jr}\right) d(g_{ij}, g_{sj})}{w_{jr}}} & if \; g_{ij} < g_{sj} \quad (28) \end{cases}$$

where parameter of θ shows the attenuation factor of losses and distance between two PFNs such as g_{ij} and g_{sj} is represented by $d(g_{ij}, g_{sj})$. By considering the distance while $g_{ij} > g_{sj}$, $\varphi_j(M_i, M_s)$ indicates a gain, that causes a loss for $g_{ij} < g_{sj}$.

The dominance degree matrix for criterion N_j composed of the function $\varphi_j(M_i, M_s)$ is written as below:

$$\varphi_j = [\varphi_j(M_i, M_s)]_{kxk} = \begin{bmatrix} 0 & \varphi_j(M_1, M_2) & \dots & \varphi_j(M_1, M_k) \\ \varphi_j(M_2, M_1) & 0 & \dots & \varphi_j(M_2, M_k) \\ \vdots & \vdots & \dots & \vdots \\ \varphi_j(M_k, M_1) & \varphi_j(M_k, M_2) & \dots & 0 \end{bmatrix}, j = 1,2,\dots,l \tag{29}$$

Then the overall dominance degree of alternative M_i over each alternative $M_s$is calculated by handling dominance degree matrix and this can be shown as below:

$$\delta(M_i, M_s) = \sum_{j=1}^{l} \varphi_j(M_i, M_s), \;\; i,s = 1,2,\dots k \tag{30}$$

Following this the overall dominance degree matrix can be constructed as follows:

$$\delta = [\delta(M_i, M_s)]_{kxk} = \begin{bmatrix} 0 & \delta_j(M_1, M_2) & \dots & \delta_j(M_1, M_k) \\ \delta_j(M_2, M_1) & 0 & \dots & \delta_j(M_2, M_k) \\ \vdots & \vdots & \dots & \vdots \\ \delta_j(M_k, M_1) & \delta_j(M_k, M_2) & \dots & 0 \end{bmatrix} \tag{31}$$

Lastly the overall value of each alternative M_i is calculated via Eq. (32):

$$\aleph_i = \frac{\sum_{s=1}^{k} \delta(M_i, M_s) - \min_i\{\sum_{s=1}^{k} \delta(M_i, M_s)\}}{\max_i\{\sum_{s=1}^{k} \delta(M_i, M_s)\} - \min_i\{\sum_{s=1}^{k} \delta(M_i, M_s)\}} \quad i = 1,2,\dots,k \tag{32}$$

Alternatives are ranked according to the descending $\aleph_i$values. That shows the better alternatives have greater $\aleph_i$ values (Ren, Xu & Gou, 2016, pp. 249-250).

4. Analysis

In this study 30 criteria related to balanced scorecard are considered for measuring the 12 retailer firms listed in BIST under this context. Criteria are evaluated by 17 experts via interval valued Pythagorean Fuzzy AHP. We suppose that 17 experts have the same weights. Pythagorean fuzzy numbers are chosen to show good and bad specifications of criteria and evaluate the alternatives under various factors. Then the

decision matrix is constructed by handling the mean of views of 17 experts related to criteria and alternatives. A part of decision matrix is given as Table 6.

Firms	Sales return	Cash cycle period	Stock turnover	Net profit margin	Accounts receivable turnover rate	Return of investments
Firm A	(0.725,0.275)	(0.4,0.6)	(0.85,0.15)	(0.6,0.4)	(0.6,0.4)	(0.725,0.275)
Firm B	(0.95,0)	(0,0.95)	(0.95,0)	(0.725,0.275)	(0.1965,0.1965)	(0.725,0.275)
Firm C	(0.85,0.15)	(0.275,0.725)	(0.85,0.15)	(0.85,0.15)	(0.725,0.275)	(0.85,0.15)
Firm D	(0.95,0)	(0.275,0.725)	(0.95,0)	(0.725,0.275)	(0.725,0.275)	(0.85,0.15)
Firm E	(0.85,0.15)	(0.275,0.725)	(0.95,0)	(0.85,0.15)	(0.85,0.15)	(0.85,0.15)
Firm F	(0.85,0.15)	(0.15,0.85)	(0.95,0)	(0.95,0)	(0.95,0)	(0.95,0)
Firm G	(0.85,0.15)	(0.15,0.85)	(0.85,0.15)	(0.85,0.15)	(0.85,0.15)	(0.85,0.15)
Firm H	(0.85,0.15)	(0.15,0.85)	(0.85,0.15)	(0.725,0.275)	(0.95,0)	(0.95,0)
Firm I	(0.725,0.275)	(0.275,0.725)	(0.85,0.15)	(0.85,0.15)	(0.85,0.15)	(0.85,0.15)
Firm J	(0.85,0.15)	(0.15,0.85)	(0.85,0.15)	(0.85,0.15)	(0.85,0.15)	(0.85,0.15)
Firm K	(0.95,0)	(0.15,0.85)	(0.95,0)	(0.95,0)	(0.6,0.4)	(0.725,0.275)
Firm L	(0.95,0)	(0,0.95)	(0.95,0)	(0.95,0)	(0.85,0.15)	(0.85,0.15)

Table 6. Decision matrix for Pythagorean fuzzy AHP

Elements in parenthesis seen as Table 6, represent the membership and non-membership degree of measurint the performance of alternative in terms of criteria respectively. After applying interval valued Pythagorean fuzzy AHP method, global weights of main criteria and sub criteria are obtained shown as Table 7.

Main criteria	Global weight	Sub criteria	Local weight	Global weight
Financial Perspective	0.236259	Sales return	0.093344	0.02205336
		Cash cycle period	0.092277	0.02180127
		Stock turnover	0.100726	0.02379742
		Net profit margin	0.113684	0.02685886
		Accounts receivable turnover rate	0.106869	0.02524876
		Return of investments	0.133497	0.03153986
		Profit/turnover	0.108377	0.02560504
		Profit/working capital	0.11624	0.02746274
		Cost of capital	0.134985	0.03189142
Internal Business Process	0.230467	Control of production costs	0.187805	0.04328285
		Team work and cooperation between departments	0.131217	0.03024118
		Participation in management	0.070901	0.01634034
		Human resource management and employee motivation	0.079462	0.01831336
		Product and quality management	0.173039	0.39879779
		New product and service development efforts	0.162014	0.03733888
		Minimizing operational issues	0.195564	0.04507104
Customer perspective	0.265513	Customer satisfaction	0.165048	0.04382238
		Customer loyalty	0.199765	0.0530402
		Recursive sales	0.176362	0.0468264
		Professionalism based customer relationship management	0.15492	0.04113327
		Customer returns	0.148211	0.03935194
		Acquired/lost customers	0.155694	0.04133878
Learning and growth	0.26776	New customer acquisition trend	0.142988	0.03828646
		Market share	0.156178	0.04181822
		Development of employees' business knowledge	0.133554	0.03576041
		Increasing the rate of productivity and capacity usage	0.174546	0.04673643
		Usage of opportunities and durability against threats	0.100386	0.02687935
		Strategic thinking and ability to predict the future	0.098249	0.02630715
		Problem solving, creativity and inventiveness	0.096419	0.02581715
		Technology utilization and research & development	0.097679	0.02615452

Table 7. Global weights of main and sub criteria

According to the results of Table 7, while the main criterion of learning and growth was found as the most important one with 0.2677 global weight, internal business process was acquired as the least important with 0.2305 global weight. According to the sub criteria while customer loyalty sub criterion was found as the most important with having 0.053 global weight, participation in management was obtained as the least important sub-criterion with 0.016 global weight.

After obtaining the weights of 30 criteria, Pythagorean fuzzy TODIM approach was applied to assess the alternatives by taking the views of 17 experts into the account. For this purpose firstly dominance degree of alternative A_i over each alternative A_t in terms of criterion C_j was constructed. Customer loyalty founded as the most important sub criterion was selected as reference criterion. Attenuation factor (θ) was taken as 2.5similar to the literature. An example of dominance degree matrix with respect to sales return under the views of 17 decision makers are given as Table 8.

Firm Codes	A	B	C	D	E	F	G	H	I	J	K	L
Firm A	0	-1.84	-1.19	-1.84	-1.19	-1.19	-1.19	-1.19	0	-1.19	-1.84	-1.844
Firm B	0.07	0	0.05	0	0.05	0.05	0.05	0.05	0.07	0.05	0	0
Firm C	0.04	-1.29	0	-1.29	0	0	0	0	0.04	0	-1.29	-1.293
Firm D	0.07	0	0.05	0	0.05	0.05	0.05	0.05	0.07	0.05	0	0
Firm E	0.04	-1.29	0	-1.29	0	0	0	0	0.04	0	-1.29	-1.29
Firm F	0.04	-1.29	0	-1.29	0	0	0	0	0.04	0	-1.29	-1.29
Firm G	0.04	-1.29	0	-1.29	0	0	0	0	0.04	0	-1.29	-1.29
Firm H	0.04	-1.29	0	-1.29	0	0	0	0	0.04	0	-1.29	-1.29
Firm I	0	-1.84	-1.19	-1.84	-1.19	-1.19	-1.19	-1.19	0	-1.195	-1.84	-1.84
Firm J	0.04	-1.29	0	-1.29	0	0	0	0	0.04	0	-1.29	-1.29
Firm K	0.07	0	0.05	0	0.05	0.05	0.05	0.05	0.07	0.05	0	0
Firm L	0.07	0	0.05	0	0.05	0.05	0.05	0.05	0.07	0.05	0	0

Table 8. Dominance degree matrix with respect to sales return

After that the overall dominance degree matrix for each A_i over each alternative A_t was constructed and shown as Table 9.

Firm Codes	A	B	C	D	E	F	G	H	I	J	K	L
Firm A	0	-7.91	-12.75	-19.89	-27.91	-34.62	-19.13	-19.29	-23.22	-22.94	-24.69	-26.57
Firm B	-17.12	0	-20.26	-21.44	-29.57	-34.19	-26.56	-24.89	-26.2	-25.45	-27.86	-26.95
Firm C	-6.19	-6.33	0	-15.41	-20.47	-28.63	-14.49	-17.45	-13.47	-17.55	-13.95	-22.82
Firm D	-6.73	-3.8	-4.46	0	16.96	-23.7	-12.79	-17.41	-12.1	-15.19	-17.27	-18.17
Firm E	-1.47	-0.53	1.3	-4.48	0	-12.99	-3.17	-10.56	-5.18	-4.52	-6.55	-8.81
Firm F	-1.68	0.99	0.43	-4.44	-0.64	0	0.56	-0.61	-3.65	-1.7	-2.98	-1.25
Firm G	-5.15	-6.79	-10.46	-16.92	-18.64	-25.49	0	-11.92	-12.08	-11.09	-19.87	-18.86
Firm H	-5.78	-5.88	-7.46	-13.52	-18.99	-19.21	-6.84	0	-13.66	-10.11	-18.68	-14.83
Firm I	-8.05	-4.89	-11.19	-15.88	-18.11	-24.06	-10.47	-16.71	0	-13.96	-20.36	-22.33
Firm J	-5.79	-1.83	-5.19	-10.57	-14.73	-22.65	-5.18	-8.89	-10.52	0	-14.3	-13.54
FirmK	-2.22	0.31	-3.334	-9.286	-9.902	-15.731	-9.161	-11.021	-10.53	-6.73	0	-9.34
Firm L	-2.83	-0.34	-1.61	-8.42	-11.45	-14.6	-5.58	-7.64	-10.65	-5.76	-6.99	0

Table 9. Overall dominance degree matrix

Following this, the overall values of the firms was calculated according to the Eq.(32) and listed as Table 10.

Firms Codes	Overall values	Ranking
Firm A	0.156595	11
Firm B	0	12
Firm C	0.390568	10
Firm D	0.624548	6
Firm E	0.841749	2
Firm F	1	1
Firm G	0.46406	8
Firm H	0.548027	7
Firm I	0.431159	9
Firm J	0.630015	5
Firm K	0.728993	4
Firm L	0.770536	3

Table 10. Overall values of the firms

According to the results of overall values of the firms, while Firm F was ranked as first having the value of 1, Firm B was ranked as last with having the value of 0. Other firms are ranked as Firm E >Firm L >Firm K>Firm J>Firm D>Firm H>Firm G>Firm I>Firm C>Firm A. As a result Firm F was found as the most successful retailer firm listed in BIST according to the views of experts. As opposed to this, Firm B was found as the least successful retailer firm listed in BIST according to the views of experts.

5. Conclusion

Balanced Scorecard allows the business to handle many non-financial measures that are not previously considered in performance appraisal, together with financial criteria. The use of many factors in the vision and mission of the business as a benchmark in the performance appraisal of business units and employees directs employees to take more action to achieve business objectives. The Balanced Scorecard method makes strategies more expressible and directing the whole of the business in this direction ensures that business units align their objectives with the strategy and reconciliation of strategies to long-term plans and budgets. The ability to develop right business processes and performance measures that are compatible with the strategies of the business is essential for faster development of new strategies and orientation of business units and employees to new strategies according to developments in the economic system in a highly competitive environment.

Pythagorean fuzzy sets are adopted for better representing the decision makers' judgments in indeterminate, uncertain and vague rather than other sets. For this purpose 30 sub criteria under 4 main criteria were considered according to the literature review. Firstly criteria were ranked according to the judgments of 17 decision makers via interval-valued Pythagorean fuzzy AHP. Following to that customer loyalty sub-criterion was found as the most important criterion and selected as the reference criterion for ranking retailer firms listed in BIST. On the other hand participation in management was obtained as the least important for measuring the performance of retailer firms. Then TODIM method, based on the prospect theory, was utilized to rank the retailer firms by handling the experts' psychological behaviours under risk. According to the results of Pythagorean fuzzy TODIM methodology, Firm F was ranked as first in terms of balanced scorecard based

performance measure. As opposed to that Firm B was ranked as the last. For future studies application area can be expanded rather than retailer firms. Also other hybrid weighting and ranking techniques (objective and/or subjective) better representing the judgments of decision makers than Pythagorean fuzzy sets can be used. Additionally firms performance can be measured by other perspectives.

References

Anderson, E. W., ve Sullivan, M. W. (1994) "The Antecedents and Consequences of Customer Satisfaction for Firms" *Marketing Science*, 12(2), 125-143.

Baynal, K., ve Karasakal, O. (2008) "İşletmelerde Performans Ölçümlerinin Balanced Scorecard ile Değerlendirilmesi ve Bir Uygulama" 28. Yöneylem Araştırması ve Endüstri Mühendisliği, İstanbul, Galatasaray Üniversitesi.

Bromwich, M. ve Bhimani, A. (1989) *Management accounting: Evolution not revolution*. London: CIMA, UK.

Calabro, L. (2001) "On Balance" *The Magazine for Senior Financial Executives*, February, 73-76.

Davis, T. R. V. (1996) "Developing an Employee Balanced Scorecard: Linking Frontline Performance to Corporate Objectives" *Management Decision*, 34(4), 14-18.

Dilanthi, A., David, B. ve Marjan, S. (2000). "Assessment of facilities management performance - what next?" *Facilities*, 18(1/2), 66-75.

Gentia (1998) *Automating the Balanced Scorecard: Maximizing Corporate Performance Through Successful Enterprise-Wide Deployment*. A Gentia Software, White Paper.

Giannopoulos, G., Holt, A., Khansalar, E. ve Cleanthous, S. (2013) "The Use of the Balanced Scorecard in Small Companies" *International Journal of Business and Management*, 8(14), 1-22.

Gomes, L. F.A.M. & Lima, M. (1992) "TODIM: basics and application to multicriteria ranking of projects with environmental impacts" *Foundations of Computing and Decision Sciences*, 16, 113-127.

Gomes, L.F.A.M. & Rangel, L.A.D. (2009) "An application of the TODIM method to the multicriteria rental evaluation of residential properties" *European Journal of Operational Research*, 193, 204-211.

Gooijer, J. (2000) "Designing a knowledge management performance framework" *Journal of Knowledge Management*, 4(4), 303-310.

Grady, M. W. (1991) "Performance measurement: implementing strategy" *Management Accounting*, June, 49-53.

Güner, M. F. (2008) "Bir Stratejik Yönetim Modeli Olarak Balanced Scorecard" *Gazi Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 10(1), 247-265.

Hoque, Z. (2014) "20 years of studies on the balanced scorecard: Trends, accomplishments, gaps and opportunities for future research" *The British Accounting Review*, 46, 33-59.

İlbahar, E., Karaşan, A., Çebi, S. & Kahraman, C. (2018) "A novel approach to risk assessment for occupational health and safety using Pythagorean fuzzy AHP & fuzzy inference system" *Safety Science*, 103, 124-136.

Johnson, H. T. ve Kaplan, R. S. (1987) *Relevance lost, the rise and fall of management accounting*. Boston, MA: Harvard Business School Press.

Kahneman, D. & Tversky, A. (1979) "Prospect theory: An analysis of decision under risk" *Econometrica*, 47, 263-292.

Kaplan, R. S. ve Norton, D. P. (1992) "The balanced scorecard – measures that drive performance" *Harvard Business Review*, 70 (1), 71–79.

Kaplan, R. S. ve Norton, D. P. (1993) "Putting the balanced scorecard to work" *Harvard Business Review*, September-October, 134-147.

Kaplan, R. S. ve Norton, D. P. (1996) *The balanced scorecard: Translating strategy into action*. Boston, MA: Harvard Business School Press.

Kaplan, R. S. ve Norton, D. P. (2001) *The strategic focused organization: How balanced scorecard companies thrive in the new business environment*. Boston, MA: Harvard Business School Press.

Kaplan, R. S. ve Norton, D. P. (2004) *Strategy maps: Converting intangible assets into tangible outcomes*. Boston, MA: Harvard Business School Press.

Kaplan, R. S. ve Norton, D. P. (2006) *Alignment: Using the balanced scorecard to create corporate synergies*. Boston, MA: Harvard Business School Press.

Kaplan, R. S. ve Norton, D. P. (2008a) "Mastering the management system" *Harvard Business Review*, 86(1), 62-77.

Kaplan, R. S. ve Norton, D. P. (2008b) The execution premium: Linking strategy to operations for competitive advantage. Boston, MA: Harvard Business School Press.

Lopes, J. L. R. (1996) "Corporate Real Estate Management Features" *Facilities Journal*, 14(7-8), 6-11.

Lynch, R. L. ve Cross, K. F. (1991) *Measure up!* London: Blackwell.

McNair, C. J., Lynch, R. L. ve Cross, K. F. (1990) "Do financial and nonfinancial performance measures have to agree?" *Management Accounting*, November, 28-36.

Nørreklit, H. (2000) "The balance on the balanced scorecard: a critical analysis of some of its assumptions" *Management Accounting Research*, 11(1), 65-88.

Nørreklit, H. (2003) "The balanced scorecard: what is the score? A rhetorical analysis of the balanced scorecard" *Accounting, Organizations and Society*, 28(6), 591-619.

Ölçer, F. (2005) "Dengeli Stratejik Performans Ölçüm ve Yönetim Sisteminin (Balanced Scorecard) Tasarımı ve Uygulanması" *Amme İdaresi Dergisi*, 38(2), 89-134.

Ren, P., Xu, Z. & Gou, X. (2016) "Pythagorean fuzzy TODIM approach to multi-criteria decision making" *Applied Soft Computing*, 42, 246-259.

Pineno, C. J. (2002) "The balanced scorecard: An incremental approach model to health care management" *Journal of Health Care Management, Summer*, 45-58.

Ritter, M. (2003) "The use of balanced scorecard in the strategic management of corporate communication" *Corporate Communications: An International Journal*, 8(1), 44-59.

Storey, A. (2002) "Performance Management in Schools: could the Balanced Scorecard help?" *School Leadership and Management*, 22(3), 321-338.

Yager, R.R. (2013) "Pythagorean fuzzy subsets" Joint IFSA World Congress and NAFIPS Annual Meeting, Edmonton, Canada, 57-61.