

A New Balancing Approach in Balanced Scorecard by Applying Cooperative Game Theory

M. Jafari-Eskandari, A.R. Aliahmadi, M. Heidari and GH.H. Khaleghi
Department of Industrial Engineering
Iran University of Science and Technology
Narmak, Tehran, Iran

Abstract

Balance scorecard is a widely recognized tool to support manager in performance of work. Balance Score Card (BSC) has many advantages but it also suffers from some drawbacks. In this paper, we develop a new balancing approach based on game theory. We propose an interaction method among different strategic agents of scorecard as players providing a methodology for collaboration among different players to reduce any inconsistency. We implement four-person cooperative game theory to balancing in BSC.

Keywords

Balanced Scorecard (BSC), Cooperative game theory, performance measurement

1. Introduction

During the past few years, balanced scorecard (BSC) has been widely used among academicians and researchers involved in strategic management and managerial accounting. The BSC, designed by Kaplan and Norton [1], uses four perspectives which reflect firm value creation activities: Learning and growth perspective, internal/business process perspective, customer perspective, and finally financial perspective. The BSC methodology creates an infrastructure for strategic management activities and introduces four new management processes contributing to linking long-term and short-term strategic objectives separately and simultaneously and use tools for doing balance in organization. BSC helps managers understand numerous interrelationships and causal effects in among perspectives [2]. This understanding can help managers to choice best strategy for organization to reduce barriers and ultimately improve decision-making and problem solving. Strategy and execution reviews can help management teams review the strategic plans, the review of planning process, including BSC metrics and strategy maps [3, 4]. Although BSC has proven a powerful tool for strategic planning and communicating strategy that assists in strategy implementation but there are some limitations on using this method. One basic issue to be surmounted is the difficulty of determining Balancing among different BSC perspective [5]. In this article, we use cooperative game theory to make predictions about four-person corporation games. The rest of this article is organized as follows. In the following section, we provide an introduction to balance score card and the cooperative game theory. In Section 3, we present methodology for combine game theory and BSC. In Section 4 one balancing system defined by the use of game theory and Finally, the conclusion remarks are given in section 5 to summarize the contribution of the paper.

2. Literature Review

2.1 Literature on the balanced scorecard (BSC)

First devised by Kaplan and Norton, the balanced scorecard approach comprises four perspectives: learning and growth perspective, internal process perspective, customer perspective, and financial perspective which seeks to offer managers a system that would help them turn strategy into action[6]. Presently, a large number of organizations are currently successful using BSC. In fact, Koning [7] mentions that recent estimates suggest that 60% of the 500 largest Fortune Organizations use BSC and also Gumbus [8] in 2005 years, mention that 64% of American Company using BSC for performance evolution. There is considerable evidence that organizations are increasingly adopting BSC in their strategic process. BSC have benefits for organization that there are some advantages:

1. Just a few numbers or performance indicators need to be checked [9].
2. Serves as a bridge between different fields (financial and non-financial fields) [10].
3. Drawing causer loop diagram for improve strategic plan [10].
4. Integrate simple plans for reduce contact in doing strategies [11].

5. Improve information management in organization [2, 12].

But it must be noted that there are some limitations:

1. Unidirectional causality too simplistic: The use of causal-loops alone is seen as problematic [13].
2. Does not separate cause and effect in time: The time dimension is not part of the BSC [14, 15].
3. No mechanisms for selected best measures for performance: The BSC concept provides any mechanism for to best defined measures [15, 16].
4. Don't selected chain value for organization: BSC cannot define chain value in strategies operation [17].
5. BSC don't dynamic for control online [18].
6. Balancing in BSC isn't actual [19].

In this paper, we using of a new approach (game theory) to solve limitation of BSC.

2.2 Background of the evolutionary game and the model

Game theory is often described as a branch of applied mathematics and economics that studies situations where multiple players make decisions in an attempt to maximize their returns [20]. Generally, the publication of the theory of Games and Economic Behavior by Morgenstern and Von Neumann in 1944 symbolizes the foundation of Game Theory system [21]. The modern game theory developed from 1950s- 1960s, and in 1970s the modern game theory became popular economic theory and behavior politics [22]. The basic concept of game theory includes: player, action, strategy, information, income, equilibrium. Initial of game theory concept is a basic modeling for function payoff for any players. The basic model of formal game theory [23]:

σ_1, σ_2 Are the actions of player1 and player 2; P is the payoff function of every player in different strategy association. Set is the set of players' strategies. If $\{\overline{\sigma_1}, \overline{\sigma_2}\}$ satisfied the following:

$$\begin{cases} P^1(\overline{\sigma_1}, \overline{\sigma_2}) = \max_{\sigma_1 \in S^1} P^1(\sigma_1, \sigma_2) \\ P^2(\overline{\sigma_1}, \overline{\sigma_2}) = \max_{\sigma_2 \in S^2} P^2(\sigma_1, \sigma_2) \end{cases} \quad (1)$$

Then strategy set $(\overline{\sigma_1}, \overline{\sigma_2})$ is Equilibrium. For game set $(\overline{\sigma_1}, \overline{\sigma_2}) \in V$, if there is no strategy set (σ_1, σ_2) satisfying the following at the same time:

$$\begin{cases} P^1(\overline{\sigma_1}, \overline{\sigma_2}) < P^1(\sigma_1, \sigma_2) \\ P^2(\overline{\sigma_1}, \overline{\sigma_2}) < P^2(\sigma_1, \sigma_2) \end{cases} \quad (2)$$

Then it is called Pareto optimality.

3. Methodologies

In this study evolutionary game theory will be used combined with balanced scorecard (BSC). Game theory has been accepted widely as the best tool for interactive decision making, while BSC on the other hand has been accepted also as the best tool in performance measurement, which is the game theory for determined balanced point in dynamic approach for organization. The model will be built in interactive framework where in making decision each player considers other possible strategies choices. This study applied a prototype BSC-Game which linked the database management, model base, knowledge acquisition, and dialogue subsystems to construct a BSC knowledge-based system for balancing by using new tools. The BSC-Game comprises three main components, as illustrated in Figure 1.

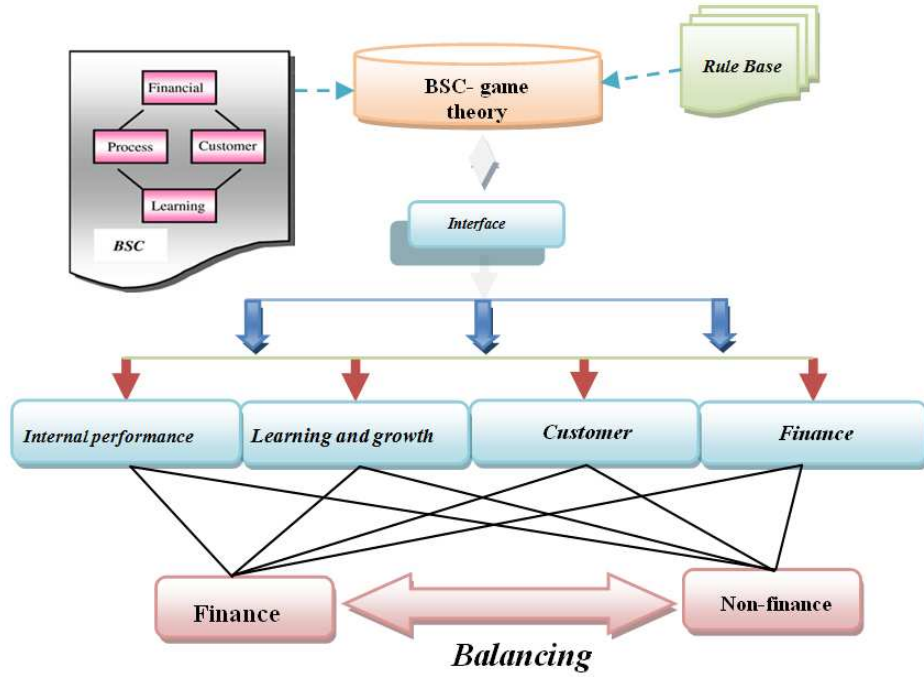


Figure 1: The architecture of the BSC- game theory system (BSC-Game)

4. Applying Cooperative Game Theory in BSC

This might be far-fetched to define the proportional probability of playing the cooperation strategy as the collaboration effort. In a cooperative game, it is natural to assume that players can make continuously varying collaboration effort.

In a four-player cooperative game, we assume that each player has a maximum resource budget, $x_{1m}, x_{2m}, x_{3m}, x_{4m}$, respectively. However four players might determine their collaboration effort during the cooperative process.

Let p_1, p_2, p_3, p_4 be the effort index of Player i ($i=1,2,3,4$). Accordingly, $p_i x_{im}$ is the total collaboration effort of Player i ($i=1,2,3,4$). We denote $B(p_1 x_{1m}, p_2 x_{2m}, p_3 x_{3m}, p_4 x_{4m})$ as common benefit of four players. Because of the efficiency of different players, we adopt $B(p_1 x_{1m}, p_2 x_{2m}, p_3 x_{3m}, p_4 x_{4m})$, which allows asymmetric efficiency between players as the benefit function. Let $C(p_i x_{im})$ be the cooperation costs of four players respectively. Thus, Player i 's payoff function can be written as follows.

$$\Pi_i(p_1, p_2, p_3, p_4) = B(p_1 x_{1m}, p_2 x_{2m}, p_3 x_{3m}, p_4 x_{4m}) - C(p_i x_{im}) \quad (3)$$

Here we would like to emphasize that we are discussing an asymmetric continuous cooperation game. If Eqs. above are concave and we obtain a vector of $\{p_1^*, p_2^*, p_3^*, p_4^*\}$ where $0 \leq p_i \leq 1$, then $\{p_1^*, p_2^*, p_3^*, p_4^*\}$ is a unique equilibrium for this asymmetric continuous cooperation game. We focus on case where the payoff functions are linear to the collaboration efforts. We have the following observation.

Table 1: The players' effort matrix

		Player 1			
		Cooperate		Defect	
Player 2	Cooperate	Player 3 (Cooperate), Player 4(Cooperate)	Player 3 (Defect), Player 4(Cooperate)	Player 3 (Cooperate), Player 4(Cooperate)	Player 3 (Defect), Player 4(Cooperate)
		Player 3 (Cooperate), Player 4(Defect)	Player 3 (Defect), Player 4(Defect)	Player 3 (Cooperate), Player 4(Defect)	Player 3 (Defect), Player 4(Defect)
	Defect	Player 3 (Cooperate), Player 4(Cooperate)	Player 3 (Defect), Player 4(Cooperate)	Player 3 (Cooperate), Player 4(Cooperate)	Player 3 (Defect), Player 4(Cooperate)
		Player 3 (Cooperate), Player 4(Defect)	Player 3 (Defect), Player 4(Defect)	Player 3 (Cooperate), Player 4(Defect)	Player 3 (Defect), Player 4(Defect)

		Player 1			
		Cooperate		Defect	
Player 2	Cooperate	$p_1 p_2 p_3 p_4$	$p_1 p_2 (1 - p_3) p_4$	$(1 - p_1) p_2 p_3 p_4$	$(1 - p_1) p_2 (1 - p_3) p_4$
		$p_1 p_2 p_3 (1 - p_4)$	$p_1 p_2 (1 - p_3) (1 - p_4)$	$(1 - p_1) p_2 p_3 (1 - p_4)$	$(1 - p_1) p_2 (1 - p_3) (1 - p_4)$
	Defect	$p_1 (1 - p_2) p_3 p_4$	$p_1 (1 - p_2) (1 - p_3) p_4$	$(1 - p_1) (1 - p_2) p_3 p_4$	$(1 - p_1) (1 - p_2) (1 - p_3) p_4$
		$p_1 (1 - p_2) p_3 (1 - p_4)$	$p_1 (1 - p_2) (1 - p_3) (1 - p_4)$	$(1 - p_1) (1 - p_2) p_3 (1 - p_4)$	$(1 - p_1) (1 - p_2) (1 - p_3) (1 - p_4)$

We show that the payoff of a player in a special continuous-strategy collaboration game can be used to describe the payoff of the player in a dynamic game. For a discrete-strategy game, we argue that the mixed strategies might be considered as a continuous effort that a player is willing to contribute to the collaboration. Thus, we can consider a mixed strategy essentially as an effort matrix (see Table 2).

In this article, we conglomerate a single factor called social punishment, which is denoted by δ . In this collaboration game, we assume that a player will be punished, e.g. his/her reputation gets hurt, etc., if he/she decides to defect while the other cooperates. We model a symmetric collaboration as shown in Table 2.

Table 2: A symmetric collaboration game

		Player 1			
		Cooperate		Defect	
Player 2	Cooperate	$b - \frac{c}{4}, b - \frac{c}{4}, b - \frac{c}{4}, b - \frac{c}{4}$	$b - \frac{c}{3}, b - \frac{c}{3}, b - \delta, b - \frac{c}{3}$	$b - \delta, b - \frac{c}{3}, b - \frac{c}{3}, b - \frac{c}{3}$	$b - \delta, b - \frac{c}{2}, b - \delta, b - \frac{c}{2}$
		$b - \frac{c}{3}, b - \frac{c}{3}, b - \frac{c}{3}, b - \delta$	$b - \frac{c}{2}, b - \frac{c}{2}, b - \delta, b - \delta$	$b - \delta, b - \frac{c}{2}, b - \frac{c}{2}, b - \delta$	$b - \delta, b - c, b - \delta, b - \delta$
	Defect	$b - \frac{c}{3}, b - \delta, b - \frac{c}{3}, b - \frac{c}{3}$	$b - \frac{c}{2}, b - \delta, b - \delta, b - \frac{c}{2}$	$b - \delta, b - \delta, b - \frac{c}{2}, b - \frac{c}{2}$	$b - \delta, b - \delta, b - \delta, b - c$
		$b - \frac{c}{2}, b - \delta, b - \frac{c}{2}, b - \frac{c}{2}$	$b - c, b - \delta, b - \delta, b - \delta$	$b - \delta, b - \delta, b - c, b - \delta$	$0, 0, 0, 0$

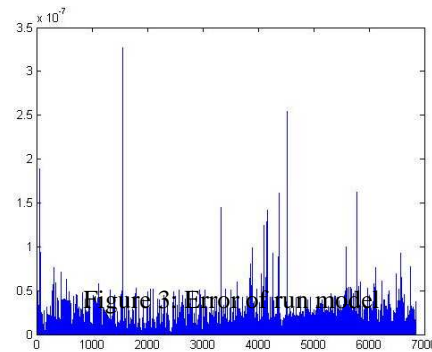
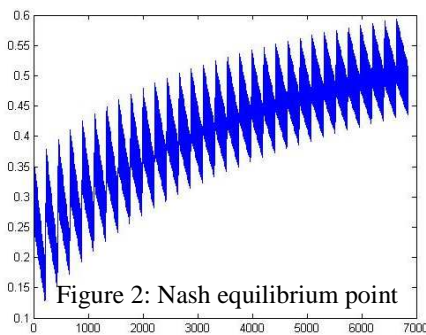
Thus, Player 1's expected payoff is given by :

$$\begin{aligned}
\Pi_1(p_1) = & p_1 p_2 p_3 p_4 (b - \frac{c}{4}) + p_1 p_2 (1 - p_3) p_4 (b - \frac{c}{3}) + (1 - p_1) p_2 p_3 p_4 (b - \delta) + (1 - p_1) p_2 (1 - p_3) p_4 (b - \delta) \\
& + p_1 p_2 p_3 (1 - p_4) (b - \frac{c}{3}) + p_1 p_2 (1 - p_3) (1 - p_4) (b - \frac{c}{2}) + (1 - p_1) p_2 p_3 (1 - p_4) (b - \delta) + (1 - p_1) p_2 (1 - p_3) (1 - p_4) (b - \delta) \\
& + p_1 (1 - p_2) p_3 p_4 (b - \frac{c}{3}) + p_1 (1 - p_2) (1 - p_3) p_4 (b - \frac{c}{2}) + (1 - p_1) (1 - p_2) p_3 p_4 (b - \delta) \\
& + (1 - p_1) (1 - p_2) (1 - p_3) p_4 (b - \delta) + p_1 (1 - p_2) p_3 (1 - p_4) (b - \frac{c}{2}) + p_1 (1 - p_2) (1 - p_3) (1 - p_4) (b - c) \\
& + (1 - p_1) (1 - p_2) p_3 (1 - p_4) (b - \delta)
\end{aligned}$$

Let $\frac{\partial \Pi_i(p_i)}{\partial p_i} = 0$ ($i = 1, 2, 3, 4$) and we obtain the optimal solution. We use an example to show the implementation of our proposed method.

5. Conclusions

Game theory, in the last decades has emerged as a powerful method to describe and to give way-outs when facing interactive problems solving. However, one big constraint to make it more applicable seemingly is in determining alternative pay-offs. Especially when the problems are dominated by qualitative considerations like what usually happens in strategic problems. Qualitative inputs cannot be processed directly by game theory. They should be translated first into quantitative inputs (pay-offs). As run the model by MATLAB software, I see that is Nash equilibrium point in $p_i = 0.5$ $i = 1, 2, 3, 4$



This paper shows how game theory can be used to balance that perspective of BSC. The research found that the best Equilibrium point for the four players in BSC is by $p_i = 0.5$ $i = 1, 2, 3, 4$. To deal with that, they need to unite their efforts and to support one another.

References

- [1] Kaplan, R.S., and Norton, D.P., 1992, "The balanced scorecards: measures that drive performance" Harvard Bus Rev 70(1):71-79.
- [2] Huang, H., 2009, "Designing a knowledge-based system for strategic planning: A balanced scorecard perspective" Expert Systems with Applications, Vol. 36: 209-218.
- [3] Kaplan, R.S., and Norton, D.P., 2004, "Strategy maps: converting intangible assets into tangible outcomes" Harvard Business School Press, Boston.
- [4] Leung, L. C., Lam, K. C., and Cao, D., 2006, "Implementing the balanced scorecard using the analytic hierarchy process & the analytic network process" Journal of the Operational Research Society, 57(6): 682-691.
- [5] Yuksel, I. and Dagdeviren, M., 2009, "Using the fuzzy analytic network process (ANP) for Balanced Scorecard (BSC): A case study for a manufacturing firm" Expert Systems with Applications, In Press.
- [6] Wong, F.W.H., Lam, P.T.I. and Chan, E.H.W., 2009, "Optimising design objectives using the Balanced Scorecard approach" Design Studies, Vol. 30: 369-392.
- [7] Koning, G. M. J. de., 2004, "Making the balanced scorecard work (part 1)" GallupManagement Journal. Http:

//gmj.gallup.com. 1-4

- [8] Gumbus, A., 2005, "Introducing the Balanced Scorecard: Creating Metrics to Measure Performance" *Journal of Management Education*, 29(4): 617-630.
- [9] Neely, A., 1998, "Measuring Business Performance" Profile Books Ltd: London.
- [10] Kaplan, R., Norton, D., 1996, "Using the Balanced Scorecard as a Strategic Management System" *Harvard Business Review* (January–February) 74 (1): 75–85.
- [11] Xiao Li, Xin Jian Gu, Zheng Gang Liu, 2009, "A strategic performance measurement system for firms across supply and demand chains on the analogy of ecological succession" *Ecological Economics*, Vol. 68: 2918-2929.
- [12] Bobillo F., Delgado M., Romero J., and Lopez E., 2007, "A semantic fuzzy system for a fuzzy balanced scorecard" *Expert Systems with Applications*.
- [13] Richmond, B., 2001, "A new language for leveraging scorecard-driven learning" Reprint from *Balanced Scorecard Report* 3(1).
- [14] Lee, A.H.I., Chen, W.C., Chang, C.J., 2008, "A fuzzy AHP and BSC approach for evaluating performance of IT department in the manufacturing industry in Taiwan" *Expert Systems with Applications*, 34: 96-107.
- [15] Cebeci, U., 2009, "Fuzzy AHP-based decision support system for selecting ERP systems in textile industry by using balanced scorecard" *Expert Systems with Applications*, Vol. 36: 8900-8909.
- [16] Leung, L.C., Lam, K.C., Cao, D., 2006, "Implementing the balanced scorecard using the analytic hierarchy process & the analytic network process" *Journal of the Operational Research Society*, 57: 682-691.
- [17] Yuksel, I. and Dagdeviren, M., 2009, "Using the fuzzy analytic network process (ANP) for Balanced Scorecard (BSC): A case study for a manufacturing firm" *Expert Systems with Applications*, In Press.
- [18] Akkermans, H.A., and Oorschot K.E., 2002, "Relevance Assumed: A Case Study of the Balanced Scorecard development using system dynamics" *Journal of the Operational Research Society*, 56: 931-941.
- [19] Pfeffer, J. and Sutton, R.I., 2000, "The Knowing-Doing Gap: How Smart Companies Turn Knowledge into Action" Harvard Business School Press, Boston, MA.
- [20] Myerson, R., 1997, "Game Theory: Analysis of Conflict" Harvard University Press.
- [21] Shapley LSA, 1953, "value for n-person games, Contributions to the Theory of Games II ":193–216.
- [22] Suijs J., Borm P., De Waegenaere A., Tijds S., 1999, "Cooperative games with stochastic payoffs" *Eur J Oper Res* 113:193–205.
- [23] Tijds S., 2003, "Introduction to game theory" Hindustan Book Agency.