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Integrating hierarchical balanced scorecard with non-additive fuzzy integral for evaluating high technology firm performance

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ABSTRACT

Efficient and accurate performance measurement systems serve as a useful tool enabling managers to control, monitor and improve high technology firm processes, productivity and performance. A model is developed for measuring the acceptable performance of high tech firms based on the interaction financial, customers, internal business process and learning and growth perspective. The HBSC structure integrated with non-additive fuzzy integral for designing, developing and implementing high technology firms relevant to performance measurement was employed to overcome interaction among the various perspectives. Sixteen samples from eight high tech firms are used throughout the study to explain how the execution of the model works. Utilizing the proposed model, the fuzzy assessment of the decision-maker and the interaction among various evaluation criteria can be a focus of the evaluation of the aggregation performance, thus ensuring more effective and accurate performance evaluation and decision-making. In the light of this empirical evidence, the results provide guidance to high tech firms performance measurement in both identification appropriate metrics and overcoming key implementation obstacles for improving firm-operating efficiency and hence assistance for future strategic adjustment.

1. Introduction

In the current extremely competitive global environment, high technology firms have been becoming increasingly reliant on core resources for maintaining long-term competitive advantage. To maintain competitive advantage high tech firms must recognize and emphasize relevant, integrated, strategic, improvement oriented and whole performance measurement systems, doing so by adopting various management philosophies and tools such as benchmarking, total quality management (TQM), and business process redesign (BPR) to help to define goals and performance expectations. High technology firms must integrate and develop appropriate performance metrics to explain and quantitatively analyze the criteria used to measure the effectiveness of the operational system and its numerous interrelated components. Balance scorecard (BSC) (Kaplan and Norton, 1992, 1996) has been developed to integrate performance measurement system with organizational goal, and aligns production, marketing, organization process, non-financial and traditional functions with firm strategies using performance driver (leading indicators) and outcome measures (lagging indicators). Consequently, the performance measurement system is entire and adopts a multidimensional structure perspective. Performance measurement is a multidimensional structure involving the various components which contribute differently to overall high technology firm performance. A systematic and efficient approach towards performance measurement is based on constructing a system model which in turn relies on corporate cross-function evaluation of performance. Evaluation methods thus must be applied together with numerous approaches to improve the accuracy of corporate performance measurement. However, performance measurement is difficult and complex and evaluators lack widely recognized performance measurement tools and well-defined criteria for making accurate measurements. Constructing and possessing available performance measurement tools not only increases evaluation efficiency but also saves costs. Traditional corporations generally use financial aspects to measure business performance, for example return on assets (ROA), return on investment (ROI), return on sales (ROS), etc. However, those traditional performance measurements suffer various limitations (Fisher, 1992; Ecceles, 1991). The most significant limitation of traditional performance measurements is that they are based on financial perspectives, which emphasize the operational results, but not the internal process would result in ignoring forecasting function and which lacks a long-term orientation.

The financial aspect comprises only part of the firm performance measurement system. Particularly, the new operational

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manufacturing environment, global competition, ease of imitation, and the information revolution represent the main reasons for firm managers not only needing to focus on financial performance but also changing their method of assessing overall performance, for example by using measurement of internal operational processes to monitor continuous quality promotion, processes improvement and innovation capabilities. In this environment firms must integrate information on financial and non-financial performance measurement systems to facilitate strategy implementation and further predict long-term performance. To measure corporate financial and non-financial performance simultaneously, the BSC proves the ability of visible performance measurement approaches in strategy implementation and management control (Kaplan and Norton, 1992). The BSC scheme integrates the interests of the key stakeholders, customers and employees on a scoreboard (Kaplan and Norton, 1996). The essence of BSC lies in seeking a balance between financial and non-financial measures.

Traditional financial indicators that use performance measures have been criticized as inadequate for the present rapidly changing business environment, especially when intangible assets rather than tangible assets are the main sources of competitive advantage for high technology firms. These intangible assets include customer satisfaction, process innovation capability, total cost reduction/control capability, etc. To overcome the limitations of financial-based measures, non-financial measures have been recommended owing to them being believed to be leading indicators of financial performance (Kaplan and Norton, 1992, 1996). Notably, practitioners and researchers have recommended increasing non-financial measures that reflect key value-creating activities, namely non-financial value drives (Kaplan and Norton, 1992, 1996; Ecceles, 1991). Non-financial information is crucial in the high technology industry, including telecommunications, biotechnology and software development (Amir and Lev, 1996). On the other hand, because of numerous non-financial indicators are difficult to quantify, including customer satisfaction, total cost control/management capabilities and employee productivities, yet they can significantly impact overall firm performance measurement. To overcome the limitations of traditional methods of measuring performance and solve problems involving difficult to quantify non-financial indicators lack sufficient information, and difficult to measure accurately. However, the previous literature seems to lack an objective definition and a consensus of the precise nature of performance measurement systems for high technology firms. This study introduces the subject by arguing about why firms need to assess performance, why they need to link performance measures to strategies or even emphasize financial and non-financial performance of firms without clearly defining the nature of a performance measurement system, and where its virtue resides in terms of management control system. Therefore, the first objective of this study is to devise a framework for developing the hierarchical balanced scorecard (HBSC) performance measurement metrics in complex and competitive operational high tech environment.

Kaplan and Norton (1996) further contended that in the BSC program a cause-and-effect relationship exists between the financial and non-financial perspectives. BSC combines important practices and concepts from various disciplines and theories into a single performance measurement system to improve financial performance. Essentially, non-financial perspectives are leading indicators, derived from establishing a causal link between improved performance in terms of non-financial and financial measures. Based on BSC, four different perspectives would be accurate the causal linkages between non-financial measures and financial measures, and focusing on improving leading indicator measures should improve the performance in terms of financial measures. Employing the HBSC method of measuring high technology firm performance should consider the interactive relationship between different perspectives. Thus, the second objective of this study is to solve the interactive impact through which the non-additive fuzzy integral provides an appropriate approach and process for handling interaction problems; this paper utilizes a properly designed and implemented HBSC structure, which should yield better results than alternative strategies. The proposed framework designed by incorporating the HBSC structure with non-addition fuzzy integral to provide an overview of high tech firm performance and prevent local optimization. The contribution of this study lies in demonstrating the limitations of a 'green field' approach in the development of HBSC to help research and practice performance measurement and enhanced management effectiveness and efficiency. The present HBSC performance measurement system is applied to overcome difficulties in performance measurement and focus on aligning the system of measuring high tech firm performance with existing performance measures and parallel initiatives cross-functional performance measures for the particular high tech firm.

Recently, many researchers have been developed and modified fuzzy analytic hierarchical process (FAHP) and analytic network process (ANP) approach in order to apply in diverse domains. Lee et al. (2008) integrate the fuzzy AHP and BSC to evaluate performance of an information technology department in the manufacturing industry. Ravi et al. (2005) analyzed alternatives in reverse logistics for end-of-life computers by combining of BSC and ANP approaches. The ANP is used to structure the hierarchy and relative weightings of interdependent performance perspectives and indicators. Chan (2006) used the AHP and BSC in implementing healthcare organizations performance assessment. The AHP is applied to calculate the relative weights for each performance assess. However, those approaches still cannot reflect the degree of interaction among performance evaluative perspectives and indicators. Therefore, non-additive fuzzy integral method was designed to solve the degree of interaction between performance perspectives and their corresponding performance indicators within HBSC. The most important component of non-additive fuzzy integral is providing information integration capability within interdependency or interactive characteristics without loss information. The proposed non-additive fuzzy integral incorporate HBSC performance measurement system could specifically design to mathematically represent uncertainty and vagueness and provide formalized tools for dealing with the imprecision intrinsic performance criteria and the degree of interaction. Since fuzziness, vagueness and interaction are coexisting characteristics existing in reality decision-making processes. These coexisting characteristics made the particular way of decision-making approach, for example, non-additive fuzzy integral is need rather general approach apply in the circumstance. Banker et al. (2004) combined a data envelopment analysis (DEA) based method with BSC analysis to assess interrelationships and tradeoff exist among alternative performance dimensions in the US telecommunications. Four quantitative performance indicators are used to adapt the framework of four perspectives of BSC. However, in their studies do not consider qualitative indicators in the model. According to Youngblood and Collins (2003) argued that although the BSC provides valuable feedback on a variety of performance metrics, but those metrics did not consider the relative importance weigh and the issue of interaction and trade-offs between metrics. Unfortunately, those approaches might hold some drawback and pitfalls in the application. First of all, these technique did not consider how to resolve the interdependent existing the quantitative and qualitative indicators. Secondly, with an interactive BSC