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Full length Research paper

Relationship between ocean-induced environmental uncertainties and navigational business performance

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Natural oceanic phenomenon, such as internal waves and ocean currents, produce rapid environmental changes which can disrupt ocean-going mass transportation and shipping. The purpose of this study is to examine the relationship between ocean-induced environmental uncertainties and navigational business performance. A number of technical models, both numerical, regression and phenomenological, have already been identified as important tools for analyzing the effects of marine environmental change. It is therefore sufficient for us to further look at two constructs: information processing requirements and information processing capability, from the balanced scorecard (BSC) perspective in relation to empirical ocean study. In this study we explore the usefulness of the "Fit" model, in relation to environmental uncertainty, technical support and BSC performance. Previous research has proven that the BSC is a good tool for measuring and evaluating firm performance. The BSC makes it possible to evaluate managerial activities from a broad perspective, which can include both tangible financial aspects and intangible, non-financial aspects, for example when evaluating the integration of technology into a business. Customer satisfaction is at the core of business performance. The BSC is a goal and action-oriented approach that can monitor and improve business performance. The BSC was originally intended to solve problems related to the historical nature of the financial measures in accounting approaches. The "Fit" model can be viewed as a core construct for information processing related to business performance. Finding the best fit between the information processing requirements and the information processing capability needed to reach the best performance, has been the initial focus for organizational consideration. However, there is relatively little in the literature linking the fit model and the BSC. The purpose of this study is to make a contribution to this literature by focusing on a major issue that that has been relatively neglected: that is, the linking of the BSC to navigational business performance a preliminary concept of fit in the context of a marine environmental model.

Key words: Balanced scorecard, navigation, business performance, regression model, conceptual framework.

INTRODUCTION

Navigation is an important part of vessel shipping and ocean transportation business performance, which is greatly impacted by oceanic forces, such as internal waves, wind-induced surface waves, and ocean currents. An ocean current is any more or less continuous, directed movement of ocean water. There is an urgent need for

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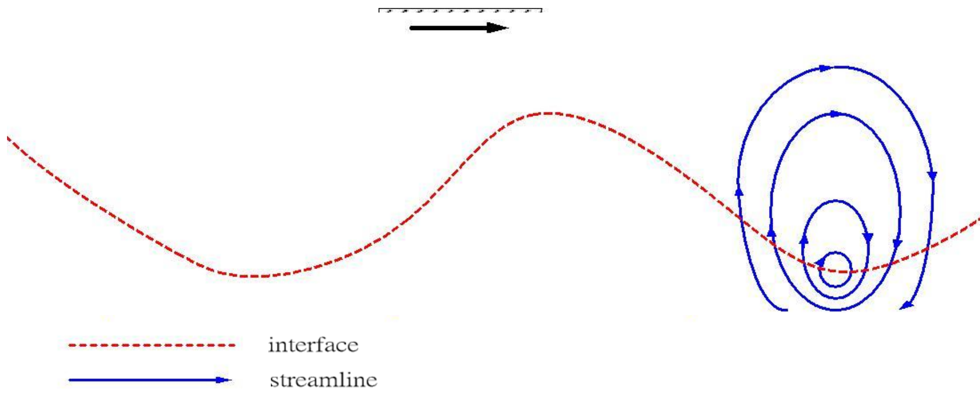

Figure 1. How the layer configuration in a two-layer system can evolve internal waves.

navigational companies to study surface ocean currents. They can use this knowledge to achieve greater fuel efficiency and thus reduce shipping costs. Today, round-the-world sailing companies employ surface currents to their benefit, although in some waters the maximum current is so swift that less powerful boats must navigate slack water.

An additional consideration is that of layer configuration. In a two-layer system, such as the oceanic environment, internal waves, unseen from the surface, can evolve which can cause sizable drag on a sailing vessel. The phenomenon is represented schematically in Figure 1. Nansen (1902), a Norwegian oceanographer, called this phenomenon “dead water”. Using laboratory experiments, Ekman (1904) found internal waves to be due to the interface between water of different densities in the interior. Waves can exist in a stratified water body where the difference in water density is mostly caused by a difference in water temperature or salinity. The simplest density structure in the ocean can be approximated by a two-layer model. The interface between layers of different densities is called the pycnoline. The steepness has an effect on navigation.

A ship can easily ride a high wave, but can be troubled by a small, steep wave. Navigational shipping firms can improve business performance simply by better understanding and predicting the evolution of internal waves. One way to do this is from the balanced scorecard (BSC) perspective.

To do this we use a regression model to investigate the relatively unknown and under -researched impact of internal waves on navigational business performance. We consider navigational business performance relative to certain objectives. This goes beyond previous studies by enabling an evaluation of the performance by modeling of the technical development by the BSC performance. The remainder of this paper is organized as follows: environmental uncertainties are highlighted. A review of the BSC from four perspectives is discussed. Laboratory experiments, numerical computations, and statistical techniques for the exploration of navigational business performance are highlighted. The concept of “Fit” is also discussed. We illustrate the core construct for information processing as a match between information processing requirements and information processing capability which enables the organization to achieve the best performance. The practical implications of BSC performance are also discussed. Finally, we conclude the examination of “Fit” by linking the overall study relationships between environmental uncertainty, technical support, and BSC performance

LITERATURE REVIEW

The BSC and performance

The BSC (Kaplan and Norton, 2001, 2004) was originally developed to solve problems related to financial measures in accounting (AICPA, 1994; Dearden, 1969, 1987; Hopwood, 1972; Johnson and Kaplan, 1987; Kaplan and Norton, 1996a; Merchant, 1985; Vancil, 1979). The BSC covers four broad perspectives related to financial aspects, customer relations, internal business and innovation and learning, as shown in Figure 2. The BSC is designed to enable managers to measure, evaluate, and guide business activities from these perspectives, as well as to enhance their problem-solving and decision-making capabilities by the examination of cross-functional relationships (Kaplan and Norton, 1992, 2004). The BSC further allows for the evaluation of managerial activities from the broad viewpoints of both tangible and intangible financial and non-financial aspects. It is an action-oriented approach to business performance improvement (Martinsons et al., 1999) allowing for the appraisal of the integration of technology processes, marketing activities, and business performance; and estimates the level of customer satisfaction by considering marketing feedback (Grembergen and Amelinckx, 2002). It reflects a customer-centric

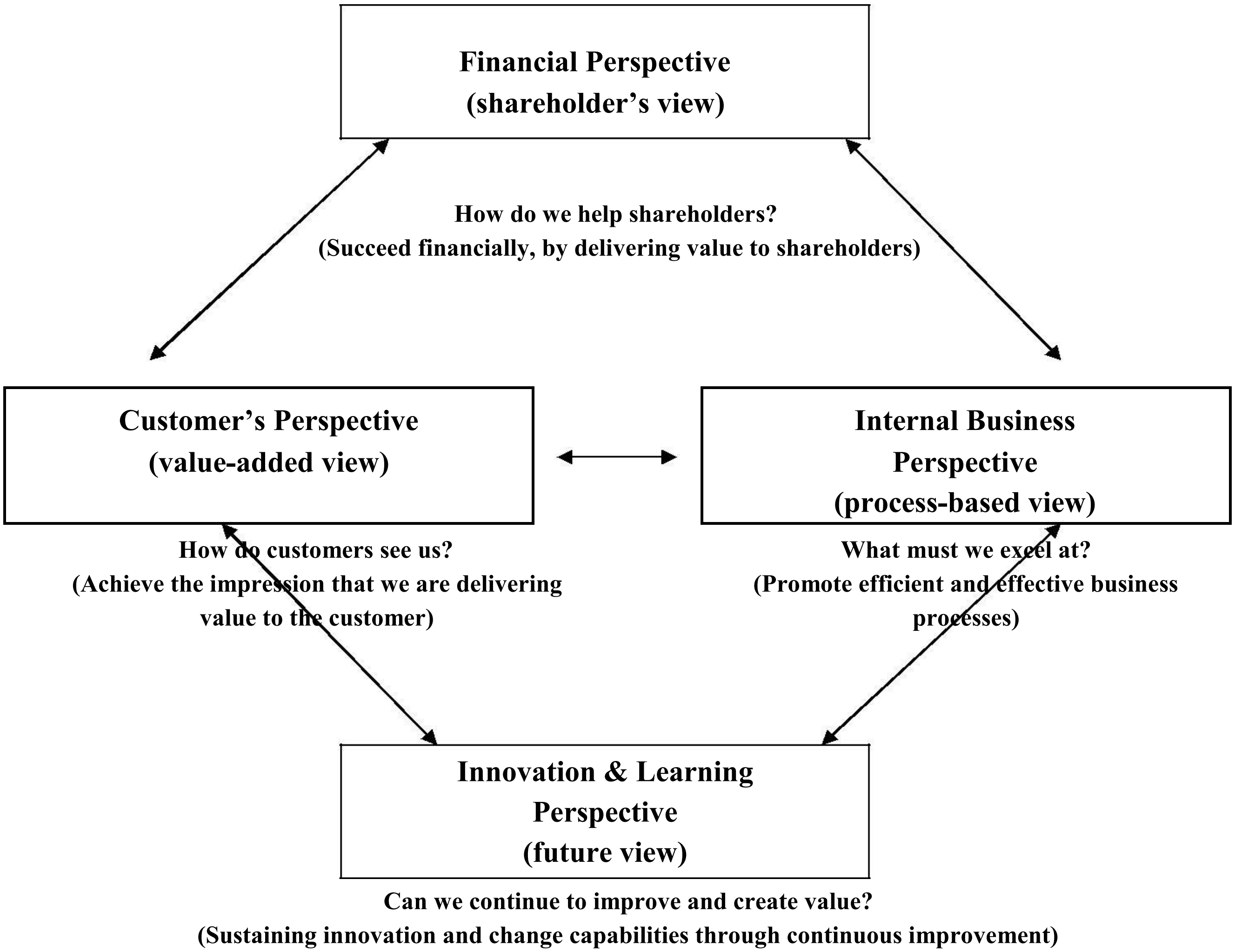

Figure 2. Kaplan and Norton (2001, 2004) balanced scorecard: linking business performance measures in ocean navigation.

philosophy based on such aspects as customer knowledge, customer interaction, customer value, and customer satisfaction (Kim et al., 2003). The BSC is a goal-oriented approach designed to advance business effectiveness by customer relationship management (Olve et al., 1999). Martinsons et al. (1999) adapted the BSC for information systems (IS) study, while Kim (2004) used the BSC perspective to connect business performance to information technology (IT) expenditure. Liyanage and Kumar (2003) used it to develop an architecture for the monitoring of managerial effects on operations and maintenance business performance. Based on prior studies, the BSC has emerged as a strategic evaluation tool for firm performance, and in this study we apply the BSC to consider navigational business performance objectives.

Four key measures

The initial financial perspectives covered by the BSC include looking at returns on investment and sales as a determinant of whether the firms' strategic implementation and execution have truly led to improvement in business activities. There are three constructs considered: increased returns on investment (ROI) and increased returns on assets (ROA) as a measure of productivity; increased profit margins as a measure of revenue growth and market share (Gumbus and Lyons, 2002); operating cost and material/asset utilization as a measure of cost structure (Ellingson and Wambsganss, 2001; Hoque and James, 2000; Maiga and Jacobs, 2003; Yeniyurt, 2003).

Customer satisfaction in the BSC is related to the measuring of service performance from customer response/feedback. This perspective includes three constructs: quality and functionality of products as a measure of product attributes; customer response time and satisfaction as a measure of customer relationship; and image and reputation as a measure of firm image (Ellingson and Wambsganss, 2001) and brand recognition (Banker et al., 2004a; Gumbus and Lyons,

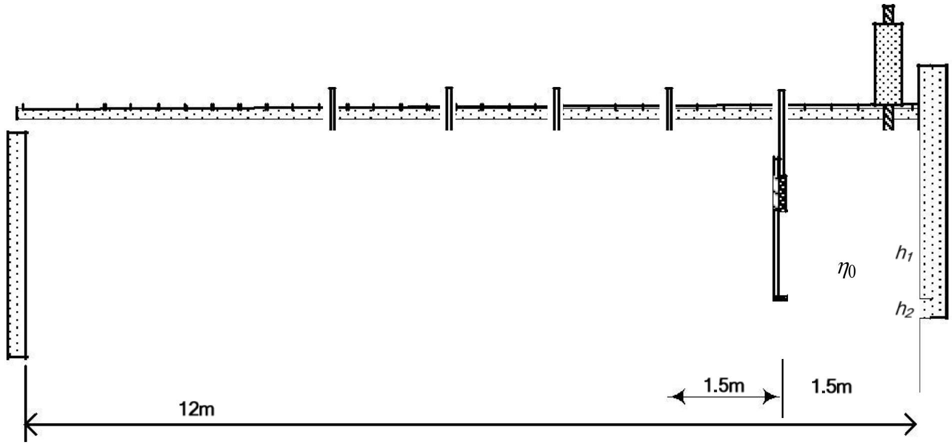

Figure 3. Schematic representation of a wave flume.

2002; Yeniyurt, 2003; Hoque and James, 2000; Kaplan and Norton, 2004; Libby et al., 2004; Maiga and Jacobs, 2003).

The internal process includes four broad constructs: operations management, measured by the quality of the operational process (Banker et al., 2004a; Gumbus and Lyons, 2002) and the dependability of the delivery process (Ellingson and Wambsganss, 2001; Hoque and James, 2000; Maiga and Jacobs, 2003; Seddon et al., 2002); customer management, measured by target customer selection (Kaplan and Norton, 2004), customer acquisition (Ellingson and Wambsganss, 2001; Libby et al., 2004) and target customer retention (Ellingson and Wambsganss, 2001; Yeniyurt, 2003) and innovation, measured by innovative opportunities (Hoque and James, 2000; Maiga and Jacobs, 2003;Yeniyurt, 2003) and time needed for product innovation (Hoque and James, 2000; Maiga and Jacobs, 2003).

Innovation and learning measures which include such items as employee skills and expertise are focused on those elements that facilitate continuous improvement and growth. In some previous studies it has been argued that a company's innovativeness in terms of the development of new products and processes is critical to achieving excellence (Banker et al., 2004b). The innovation and learning perspective includes three broad constructs: human capital, measured by employee skills (Ellingson and Wambsganss, 2001; Libby et al., 2004; Ullrich and Tuttle, 2004) and know-how (Kaplan and Norton, 2004) organization capital, measured by sharing of worker knowledge (Kaplan and Norton, 2004) and shared vision, objectives and values (Kaplan and Norton, 2004) and information capital, measured by knowledge management capabilities (Kaplan and Norton, 2004) and accessibility of information (Kaplan and Norton, 2004).

TECHNICAL SUPPORT AND DEVELOPMENT

Most oceanographers understand very little about internal wave propagation, although efforts are being made through laboratory experiments, numerical computations and statistical techniques to increase this knowledge. These efforts can be used as tools to improve navigational business performance.

Laboratory experiments

Laboratory experiments on ISW propagation were conducted using a two-layer fresh/brine stratified fluid system in a steel-framed wave flume, 12 m long, 0.7 m high and 0.5 m wide (Chen et al., 2006, 2007a, 2008a, 2008c, 2008e, 2009, 2010a; Tseng et al., 2009). The wave flume used to simulate internal wave propagation with regard to the local topography and to observe wave evolution on a variable seabed is depicted in Figure 3. The dynamic mechanism for variation in ISW shoaling over different slopes can be illustrated with a mirror-image model (Chen et al., 2007b). This model can predict wave variation during its journey along a sloping bottom. The level of wave- ridge interaction can be determined by a simple blockage parameter, as demonstrated by Chen et al. (2006a, 2006b). The internal waveforms are also influenced by the fresh/brine water head on either side of the gate used in our experimental setup.

Numerical computations

A set of mathematical expressions has recently been derived to define ISW propagation on a variable seabed in a two-layer fluid system; see Figure 4 By neglecting the terms representing viscous effects, the exact forms of the governing equations can be solved for wave evolution on a variable topography. The wave profile calculated from the modified numerical model is in better agreement with the laboratory experiments (Guo, 2004; Chen et al., 2006c, Cheng et al., 2009; Chen et al., 2010b).

Statistical techniques

It is difficult in applied engineering to undertake overall estimation with efficiency and effectiveness. Chen et al. (2007a) developed a widely used statistical scheme for the examination of the functional relationships among

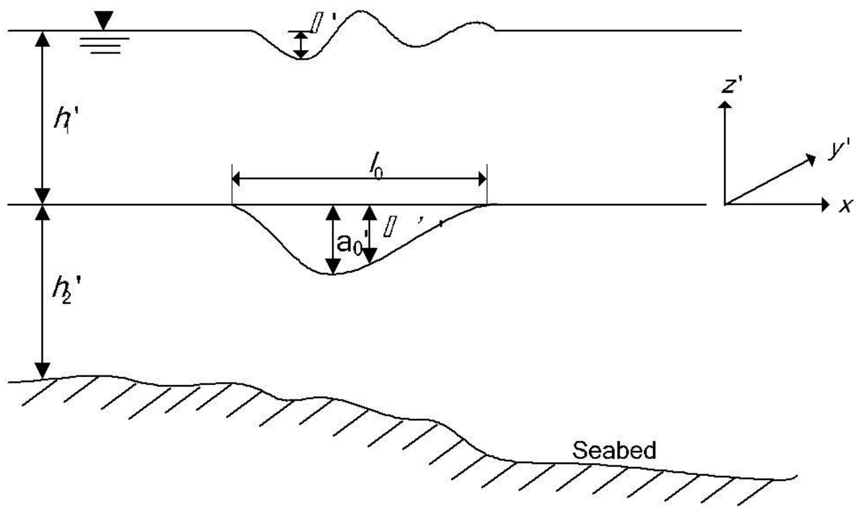

Figure 4. Sketch defining ISW propagation on a variable seabed in a two-layer fluid system.

variables. Chen et al. (2008b, 2008d) also successfully applied the adaptable statistical tool of the cumulative logistic regression model (CLRM) to better predict the natural oceanic phenomenon of the ISW. Indeed, in comparison with the binary logistic regression model (BLRM), the CLRM has been identified as a significant way to measure nonlinear internal waves. Appropriate statistical techniques can be used to estimate energy dissipation in regional seas (Chen, 2010c).

"FIT" MODEL FOR BUSINESS PERFORMANCE

Conceptual model

We outline our "Fit" model in Figure 5. Technical support that helps to predict the propagation of ISWs over submerged ridges can include laboratory experiments, numerical models and regression algorithms. This support plays an important role linking changes in the marine environment and business performance. If we expand and improve the technical support we can improve navigational business performance in terms of shipping management, transportation studies, and even the problem of shipping to remote islands. In other words, appropriate technical support can be utilized to overcome environmental uncertainty and thus improve business performance.

Fit is a common construct used in the information system field to explain the relationship between various variables and their effect on specific outcomes. For instance, from the information processing point of view it can be stated that it is necessary to achieve the closest fit between information processing needs and information processing capability to reach optimal organization performance (Tushman and Nadler, 1978). A core construct of the "Fit" model is the relationship between information processing and business performance. The best fit between the information processing requirements and the information processing capability needed to produce the best performance should be the initial focus of organizational consideration (Daft and Lengel, 1986; Galbraith, 1973; Tushman and Nadler, 1978). Drazin and Van de Ven (1985) used three ways to evaluate fit—selection, interaction, and systems. Venkatraman (1985) studied fitness using statistical methodology and implicit assumptions made at both theoretical and empirical levels. Based on this, Daft and Lengel (1986) suggested that the amount and enhancement of information processing should match the level of business task/environmental uncertainty. They interpreted contingency theory using the concept of priority, and then proposed using the fit between information requirements and information processing capability to promote better business unit performance. The purpose of this study is to investigate the fit between the information processing requirements needed to face the natural phenomenon of ocean forces and the information processing capability needed to predict wave evolution on a variable seabed topography. Specifically, we apply information processing to navigational business performance. The basic research model is shown in Figure 5.

The research model used in our study uses two main constructs; information processing requirements and information processing capability. Consistent with the prior definition of fit in information processing theory, we investigate information processing requirements, information processing capability, the fit between the two, and the effect of this fit on business performance. In other words, we develop taxonomies for information processing requirements for a navigational business based on the theoretical factors that contribute to environmental uncertainty. Using Venkatraman's (1985) suggestions for developing taxonomies, we define the categories of natural oceanic force phenomena based on the internal

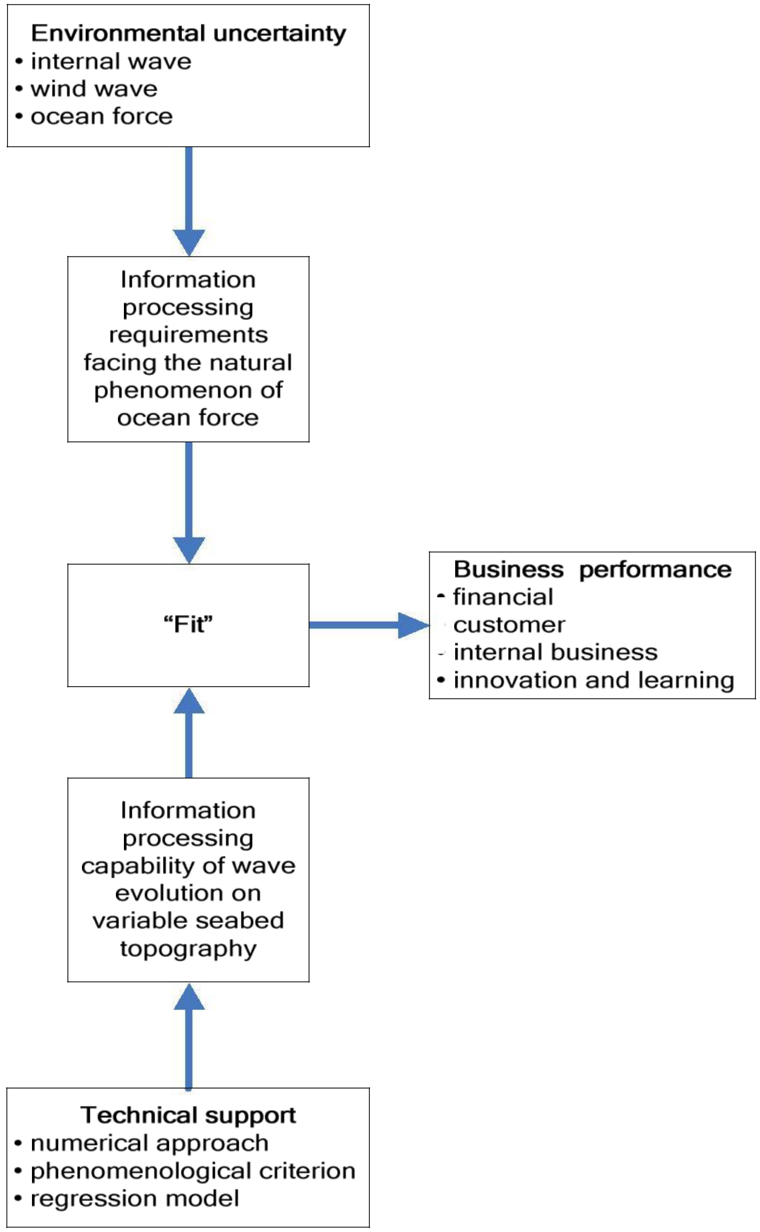

Figure 5. "Fit" model of the relationship between business management and technical tools.

coherence of a set of attributes, in this case internal waves, wind waves, and ocean forces. In addition, we measure information processing capability for predicting wave evolution on a variable seabed using the technical support tools of a numerical approach, phenomenological criterion, and regression model. In short, fit is viewed as a complex construct for matching the interaction between requirements and capabilities. As suggested by Venkatraman (1985), there are several ways to conceptualize the fit between these two variables, and the choice should be based upon theoretical conceptions founded on empirical measurement. We consider "fit as matching" in Venkatraman's (1985) taxonomy to be the best conceptualization of the fit model for theoretically defining and matching two related variables. Moreover, this conceptualization is similar to the "interaction" approach to evaluation of fit, since the interaction of the two variables could have a significant effect on the outcome variable of interest to the researcher (Drazin and Van de Ven, 1985; Venkatraman, 1985).

Navigational business performance: the BSC perspective

Kaplan and Norton (2001, 2004) adapted the BSC to measure organizational performance from the four perspectives of finance, the customer, innovation and learning and internal business. They claimed that the traditional financial accounting models were designed in the industrial age to control employee behaviors. However, the BSC process starts with the senior executive management team working together to translate a unit's strategy into specific strategic objectives. In this study we use the BSC to measure navigational business performance, where energy dispersion can be caused by the natural phenomena of ocean forces and regional environmental changes, which of course, have effects on the navigation in terms of transportation time, oil and energy used, and risk and safety.

Kaplan and Norton (2001) suggested that the customer perspective values can be classified into three categories:

(a) Product and service attributes, (b) customer relationships and (c) image and reputation. Here we investigate the customer relationship dimension of the BSC with regard to navigational business delivery of products or services to the customer, including response and delivery times, as well as how the customer feels about their purchasing experience with this company. These factors are an indication as to how the navigational company manages customer relationships and maintains product and service value. This aspect of value creation, that is, satisfying the customer's navigational/shipping needs, is well modeled by the internal business process perspectives of the BSC. The creators of the BSC, Kaplan and Norton, suggested that each business has its unique set of processes for creating value for customers (Kaplan and Atkinson, 1998). By creating value the navigational company can acquire, satisfy and retain customers. Following the generic value chain model, Kaplan and Norton (1996b) suggested that it is value creation efforts in the internal business process that have the greatest impact on customer satisfaction. Kaplan and Norton's (2001) concepts are closely tied to the navigational marketing relationship value that is at the core of this study. Based on their research we define four major aspects of organizational performance as a measure of navigational business performance: customer loyalty, internal process efficiency, channel management, and innovation.

Customer loyalty has been a major issue in marketing for over half a century, and a sizeable literature on the subject has evolved. Customer loyalty is defined as the strength of the relationship between the buyer and the seller and the customer's attitude to repeat purchases (Dick and Base, 1994). Customer loyalty is the foundation for strategic market planning/implementation and is an important part of developing/maintaining a sustainable competitive advantage (SCA). The concept of customer loyalty has been characterized using both stochastic and the deterministic approaches (Odin et al., 2001). The former views loyalty as behavior and defines loyalty as customers who buy the same brand systematically. Evaluation measures, include proportion of purchase (Cunningham, 1996), purchase sequence (Kahn et al., 1986) and probability of purchase (Massey et al., 1970). In the deterministic approach on the other hand, loyalty is viewed as the "psychological commitment" of consumers to the purchase regardless of actual purchase behaviors. Customer loyalty increases with the frequency of purchasing of products and services. Accordingly, we note that for a navigational company to attain this type of customer loyalty, they should offer value-added services to improve service support, such the building of attractive websites or using advertising to attract shipping customers. Proper BSC practices have the potential to improve customer satisfaction ratings and increase customer retention, which in turn enhances customer loyalty. Customers can be influenced to show preferential attitudinal and behavioral responses toward one or more brands in a product category over a period of time. Customer loyalty can thus be defined here as the customer's favorable attitude toward navigational products and services that result in repeat buying behavior, increased retention of customers, increased repurchasing rate, and increased frequency of cross sales.

The internal navigation process, especially proper and rapid service delivery to customers and/or prompt response to customer navigational wants and needs, has a critical impact on the customer relationship. Thus, the emphasis should be on customer-oriented actions. This can be viewed as a major motivation for improving the efficiency of the internal navigational process, so that customers' expectations can be met. Improvements in ocean technology provide the navigational service provider with the capability to meet customer needs through a variety of different channels. The integration of all channels should give customers a single and comprehensive view of the navigational service company so that they will not be confused by too many possible interactions. Channel management can thus be viewed as a way to coordinate and synchronize communications across all possible customer touch-points. Therefore, efficient channel management means that the navigational service company provides multiple information delivery channels, where customers conveniently receive consistent marketing information through the available channels. To do this it is necessary to solve channel conflicts resulting from multi-channel competition.

Again, as pointed out by Kaplan and Norton (1992), a company's ability to innovate, improve, and learn closely is tied to a navigational company's value. With regard to the BSC, the ability of the navigational service company to launch more effective navigational services can increase value for both the supplier and customers. Thus, innovation here can be viewed as the continual improvement of existing products and services and the ability to develop new marketing services with expanded navigational capabilities.

BSC PERFORMANCE: PRACTICAL IMPLICATIONS

Previous research has suggested that the BSC is a useful tool for measuring and evaluating firm performance. The BSC makes it possible to evaluate managerial activities from a broad viewpoint, by looking at both tangible financial aspects and intangible non-financial aspects. We can use this method to evaluate the integration of business and technology. Customer satisfaction is a core part of business performance. The BSC is a goal and action-oriented approach that can be used to monitor and improve business performance. Thus, the four BSC perspectives applied to business performance measures are discussed below.

To succeed financially a navigational business should reach the following goals: profitability, continuing liquidity and solvency in both the short and long run, increasing sales turnover and maximizing of shareholder profit. Therefore, the main financial objectives can briefly be defined as surviving, succeeding and prospering. Survival can be viewed as cash flow, success can be defined as sales growth and greater operating income and prosperity can be measured as increased market share and return on equity and capital employed. Finance and logistics costs, such as assets costs, returns on investment, and total navigational shipping costs, are used to assess the financial performance of a navigational business. We conclude that the financial perspective broadly covers navigational business query time, net profit vs. productivity ratio, rate of return on investment, customer-supplier relationship, navigational delivery performance, business costs and savings, navigational delivery reliability, the cost per navigational business operation day, information and technology cost, and navigational business rejection rate.

The customer performance measures are related to the evaluation of the business activities needed to achieve the goals of delivering ever increasing value to the customer. The management of a navigational business can express and communicate their general mission to their customers via specific measures, such as lead-time, quality of products and services, navigational business service performance, and cost effectiveness. The purpose of customer navigational business service and satisfaction is to link the customer's specifications and set the elements of quality as their feedback for the business control process. Customer performance measure can include improvements in navigational product/service flexibility, customer query time, post-transaction service, customer perception of the value of products and services, order lead time, business performance to meet specific customer needs, delivery performance, effectiveness of delivery invoice methods and reliability, responsiveness to urgent deliveries, effectiveness of the distribution planning schedule, information flow cost, quality of delivery documentation, driver reliability (which means driver safety which in turn leads to secure shipping) for business performance, and ensuring of defect-free/partial charge deliveries. The internal business perspective is related to the efficiency and effectiveness of business processes which have an impact on customer satisfaction, such as business cycle time, quality, employee skills, and productivity. Navigational business units should know what navigational processes and competencies they must excel at and specify measures for meeting these standards. This can broadly include total navigational business cycle time, overall cash flow time, flexibility of service to meet particular customer needs, supplier lead time against industry norms, level of supplier's defect-free/partial payment deliveries, accuracy of forecasting navigational techniques, navigational planning process, delivery service, purchase order cycle time, effectiveness of the production schedule, capability utilization, total inventory cost, stock level, and frequency of delivery.

The innovation and learning perspective is aimed at sustaining innovation and maintain capabilities by continuous business improvement and growth. The innovation, improvement and learning of business units have a direct impact on corporate value. Continuous innovation and learning can increase the business operation efficiency by strengthening financial competitiveness through increased profitability and earnings per share. This can broadly include supplier assistance in solving navigational/technical problems, supplier capability of dealing with quality problems, supplier cost saving, business booking procedures, capability utilization, order entry methods, accuracy of navigational forecasting techniques, business development cycle time, understanding what service systems are required to meet particular customer wants, customer -supplier relationships, range of navigational products and services and customer-perceived value with regard to the navigational business product.

CONCLUSION

The purpose of this paper is to investigate empirically ISW propagation using statistical and technical tools and to predict navigational business performance based on the BSC perspective. The "Fit" model was adapted to link environmental uncertainty, technical support and BSC performance. Natural phenomena in the marine environment, such as internal waves, wind-blown waves, tides and water layer stratification are affected by oceanic energy dispersion, which is in turn affected by ridge height, seabed topography and coastline configuration. This paper identifies and suggests several technical tools, such as laboratory experiments, numerical calculations and regression models that can be used to better understand these forces. This approach should help to solve regional environmental uncertainty which affects navigation at sea, such as in the Taiwan Straits, South China Sea, Andaman Sea and so on. We suggest applying Kaplan and Norton's (2001 and 2004) BSC, which includes the perspectives of financial, customer, internal business and innovation and learning measures, to consider the relationship between effects of marine environmental change and the given technical tools on navigational business performance.

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