Supplier Relational Integration Under Conditions of Product Complexity

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While supplier integration is said to have a positive impact on performance, anecdotal evidence suggests that integration is difficult and is seen more commonly at an operational level rather than at a strategic or relational level. Studies have questioned the benefits of integration under certain conditions. This study examines the impact of supplier relational integration (SRI) on supply chain and firm performance; and proposes greater benefits from supplier relational integration under conditions of product complexity (PC). Findings from a survey of 270 manufacturing firms indicate a strong positive impact of SRI on performance. However, the moderating effect of PC is not supported, indicating the possible role of supply base complexity. Implications for theory and practice are discussed.

INTRODUCTION

Researchers and practitioners have in the past addressed the issue of integration between manufacturers and their suppliers (e.g., Lambert et.al., 1978; Armistead and Mapes, 1993; Narasimhan and Kim, 2002; Flynn et.al., 2010). Supplier integration has become common practice in the manufacturing sector. Supplier integration has been implemented to varying degrees in the supply chain (Childerhouse and Towill, 2011). Researchers have identified supplier integration to span the breadth of the supply chain from product development (e.g., Koufteros et.al., 2007; Peterson et.al., 2005) to logistics and distribution (e.g., Zhou and Benton, 2007; Chopra, 2003). Some studies have addressed the extent of integration from the perspective of breadth of integration (Frohlich and Westbrook, 2001; Flynn et.al., 2010), while other have differentiated between integration at operational and strategic/relational level (Stevens, 1989).

Despite all the attention that supplier integration has garnered, the fact remains that integration is not easy to achieve and calls for substantial investment of resources for all parties involved (Stevens, 1989). It is for this very reason that recent studies have questioned whether integration is always beneficial (eg: Zhao et.al., 2015; Das et.al., 2006). Thus, it makes sense to (a) explore the degree of integration necessary and (b) examine conditions under which integration is more/less beneficial. Degree of integration as a determinant of success outcomes has been explored in the past (eg: Zhao et.al., 2015; Frohlich and Westbrook, 2001). However, there is scope to further examine conditions under which integration is pursued. This study therefore focuses on the latter and addresses the nature of conditions under which integration is pursued.

Integration of systems and activities is generally explored as a solution under conditions of uncertainty and task complexity. It is because information processing and managing information flow becomes difficult under such conditions (Galbraith, 1974). One such situation in the supply chain is when the product (being manufactured or managed) is inherently complex. This is a trend that we have seen

over time. We notice that the complexity of products being manufactured has gradually increased over time. In the quest to manage the effects of increasing levels of product complexity in the supply chain, companies have explored various options. One option is to consciously decrease the complexity of the product. However, this might not be a feasible solution since customers expect products with more/better features and functionalities, which eventually makes the product more complex (Novak and Eppinger, 2001). The other option that manufacturers have embraced involves integrating with suppliers across the supply chain to better manage activities and information flows. This is said to increase the ability of the supply chain to achieve coordination in the face of complexity. However, since supplier integration requires time, effort and commitment of resources, it would be worthwhile to understand the conditions under which integration is more valuable. Thus, this study examines the effect of product complexity and addresses the following research questions: (1) What is the effect of supplier relational integration on supply chain and firm performance? and (2) Is supplier relational integration more beneficial when the product in question is more complex?

To address these research questions, this paper presents a research model that outlines (1) a direct relationship between supplier relational integration and supply chain efficiency; (2) a direct relationship between supply chain efficiency and firm performance; and (3) a moderating effect of product complexity on the relationship proposed in (1). Data collected from a survey of manufacturing firms in the US is used to empirically test the proposed relationships. The results of the study suggest a positive relationship between supplier relational integration and supply chain and firm performance. The results however do not support the moderating effect of product complexity. The lack of support for the moderating effect of product complexity throws light on broader supply chain or supply base related factors that may in fact have a stronger influence on the integration-performance relationship. Nonetheless, this study contributes to theory and practice in many ways. First, it reinforces the positive effects of supplier integration on supply chain and firm performance. Second, it specifically focuses on supplier relational integration and its various sub-components. Third, it provides guidelines for managers on how to achieve strategic or relational integration and how to manage the effects of complexity. The rest of the paper is structured as follows. The next section presents a literature review, which is followed by hypotheses development, methodology and empirical results. Finally, the implications of the study, limitations and scope for future research are discussed.

LITERATURE REVIEW

Supplier Integration

Integration in general is defined as ‘‘the unified control of a number of successive or similar economic or especially industrial processes formerly carried on independently’’ (Webster’s 1966, p.1175). In the context of supply chain management, the idea of integrating the focal firm and its suppliers has been widely discussed. Previous studies have referred to Supplier integration in terms of the degree to which a firm collaborates with its suppliers in order to manage inter-organizational processes that lead to the fulfillment of customer demands (Zhao et.al., 2015; Huo, 2012; Zhao et.al., 2011). The degree of supplier integration and the points of supplier integration have captured the attention of researchers in general. For instance, Peterson et.al., (2005) address possible points of integration in the product development process which range from the idea generation stage to the prototype stage. Koufteros et.al. (2005) conceptualize supplier integration in terms of supplier process integration and supplier product integration. However, if we look at management literature in general, we see that integration has been examined in terms of operational integration and strategic integration. This is an interesting distinction within the concept of integration and this study thus further builds on this distinction to explore performance effects.

Supplier Relational Integration

In the context of supplier integration, a distinction can be made based on the level and the primary intent of integration (Swink et.al., 2007). At one end, researchers have looked at supplier integration from

a purely operational perspective where the focus is on coordination of day-to-day activities and management of material movements, ordering processes and numerous other short-term transactions (Sahin and Robinson, 2002). On the other hand, studies have also addressed the strategic nature of supplier integration activities. The focus in that case is more long term, and collaborative in nature. It calls for building relationships between supply chain partners, sharing information and designing collaborative processes (Narasimhan and Kim, 2002; Shah et.al., 2002). Based on this distinction, this study explores the issue of strategic supplier integration by looking at it in terms of Supplier Relational Integration (SRI). Supplier Relational Integration is defined as the extent to which the focal firm collaborates with its suppliers to manage long term and strategic activities. This includes a variety of activities that are aimed at creating closer relationships between a firm and its suppliers. These activities go well beyond merely having arm's length relationships with suppliers. The idea behind relational integration with suppliers is to establish true partnerships and not just transactional relationships.

In order to capture the essence of integration, this study proposes three key elements of integration – Information sharing, Decision synchronization and Collective learning. Information sharing is seen as a key element of integration, be it at an operational level or at a strategic level (Swink et al., 2007; Sahin and Robinson, 2002; Narasimhan and Kim, 2002). Information sharing is the foundation for any kind of integration between supply chain partners. It creates visibility and reduces uncertainty (Lee et al., 2000; Lee et al., 1997). At the relational level, Information sharing is seen as the extent to which a focal firm and its suppliers exchange strategic information.

The second element of integration is proposed to be Decision synchronization. Synchronizing decisions between supply chain partners helps balance supply and demand. Lack of synchronization would result in a supply chain with either excess inventory or stock outs. Synchronization generally involves getting together and making joint decisions that are aimed at reaching the identified objectives. At the relational level, Decision synchronization is defined as the extent to which the firm makes joint decisions concerning strategic planning activities with its suppliers.

Collective learning is proposed to be the third element of supplier integration. The ability to learn from a partner in order to improve operations is key to the success of any partnership. Integration of activities thus revolves around the willingness of partners to share and learn from each other. Collective learning enables the creation of shared procedures and processes in the context of integration (Lazaric and Lorenze, 1998). At the relational level, Collective learning is defined as the extent to which the firm and its suppliers jointly develop knowledge and competencies to manage long term strategic activities.

Supply Chain Efficiency and Firm Performance

Efficiency in general refers to "doing things right". Efficient supply chains are the ones that can minimize cost and inventory build-up throughout the chain (Fisher, 1997). Some of the best performing supply chains (such as those of companies like Walmart, Dell, HP etc.) are also known to be the most efficient. They manage to optimize cost and inventory levels and at the same time ensure high levels of customer service by providing reliable delivery. Efficient supply chains are also known to reduce lead times and minimize variability throughout the system (Yeung et.al., 2008; Li and O'Brien, 1999). In this study, Supply chain efficiency refers to the extent to which the supply chain optimizes cost, inventory and delivery performance.

Firm performance can be assessed from an operational perspective and from a market perspective (e.g. Holmberg, 2000; Tan et al 1999; Huselid et al 1997; Baker and Sinkula, 2005). The operational perspective delves into whether the firm is performing well in terms of cost, quality, delivery reliability and flexibility. The market perspective looks at market indicators such as revenue growth, market share etc. Ultimately the determinant of a firm's performance is its ability to achieve competitive advantage by creating a defensible position over competitors (Li et al 2006). This study thus defines Firm Performance as the extent to which the firm meets its competitive goals.

Product Complexity

Over the years, we have seen that products being manufactured have gradually become more and more complex. There are many reasons for the increase in complexity. Customers' need for products with improved capabilities and increased features has sent the manufacturers on a race to produce products that satisfy these requirements. At the same time, improvements in manufacturing technology have helped create more complex products.

A complex system in general is "one made up of a large number of parts that interact in a non-simple way'' (Simon, 1996, p. 468). This definition identifies two things – numerousness and interactions. Numerousness has been addressed in terms of multiplicity in the context of product complexity. Both numerousness and multiplicity in this case refer to the number of components that make up the product system or the number of sub-systems that make up a product (Novak and Eppinger, 2001). Interaction in this context refers to the extent to which the various sub-systems are interconnected. In a complex product, the close interaction between the various sub-systems means that a change in one part of the system will necessitate changes in other parts of the systems as well (Khurana, 1999; Novak and Eppinger, 2001). Another aspect of product complexity is the novelty of the product. Product novelty refers to the newness of the product and/or its associated product architecture (Tatikonda and Rosenthal, 2000; Hobday, 1998). It takes time for manufacturers to understand the complex interactions associated with a new product and managing a new product is considerably more challenging (Kim and Wilemon, 2003). Technology intricacy which refers to the complexity of the core technology is another important component of product complexity. As with product novelty, technology intricacy creates initial challenges and challenges continue while various aspects of the technology unravel over time (Singh, 1997). Product Complexity is thus defined as a state of difficulty that is a function of component multiplicity, component interactions, product novelty and technology intricacy.

HYPOTHESES DEVELOPMENT

A close relationship between manufacturers and their suppliers creates opportunities for improving various inter and intra organizational processes. These close relationships have to be fostered, nurtured and orchestrated over time. Information sharing is the starting point for achieving close relationships. Information sharing is the foundation for integration between supply chain partners. It ensures that actors across the chain are on the same page by ensuring demand visibility, which is extremely critical for balancing supply and demand (Li et al 2005). Sharing information that is strategic in nature can be extremely beneficial (Chu and Lee, 2006). For instance, sharing long term plans for products/customers, technology trends and forecasts ensure that suppliers are adequately geared up and prepared for things to come. Studies have shown that sharing strategic information can reduce inventory cost and increase fill rate (Li et.al., 2006).

Decision synchronization by means of joint decision making is a key component of supplier integration and these decisions can be operational or strategic in nature. At the strategic level, firms and suppliers make joint decisions to design their supply network. For instance, facility location is one such long term decision that provides efficiency benefits for years to come (Bagchi et.al., 2005). Other long term joint decisions that contribute to improved efficiency include things such as technology selection, capacity planning etc.

Collective learning, which is the third dimension of supplier integration, delves into joint learning and development of competencies. Joint learning activities are said to improve efficiency by reducing time, effort and money that goes into various activities (Wright, 2000; Humphreys et.al., 2003; Song et.al., 2009). For instance, as evidenced in the automotive industry, collective learning with suppliers helps improve operational efficiencies by streamlining production processes, reducing defect rate and improving material flows. In the context of product development, strategic learning arrangements between supply chain partners leads to development of improved products, shorter lead times and shorter time-to-market (Peterson et.al., 2005).

Thus, this study proposes:

H1: Supplier Relational Integration is positively related to Supply Chain Efficiency.

Firms today realize that they have to look beyond their organizational boundaries to improve their firm performance. Firms like Walmart exert control over multiple echelons of their supply chain for this very reason. In most manufacturing firms, over sixty percent of their cost is from the purchase of raw materials and components that go into the production process. Every dollar saved in the procurement process adds to the bottom line of the firm. As a result, a firm's success largely depends on its ability to keep supply chain costs low, reduce lead time throughout the supply chain and achieve reliable deliveries (Hendricks and Singhal, 2005). Thus, this study proposes:

H2: Supply Chain Efficiency is positively related to Firm Performance.

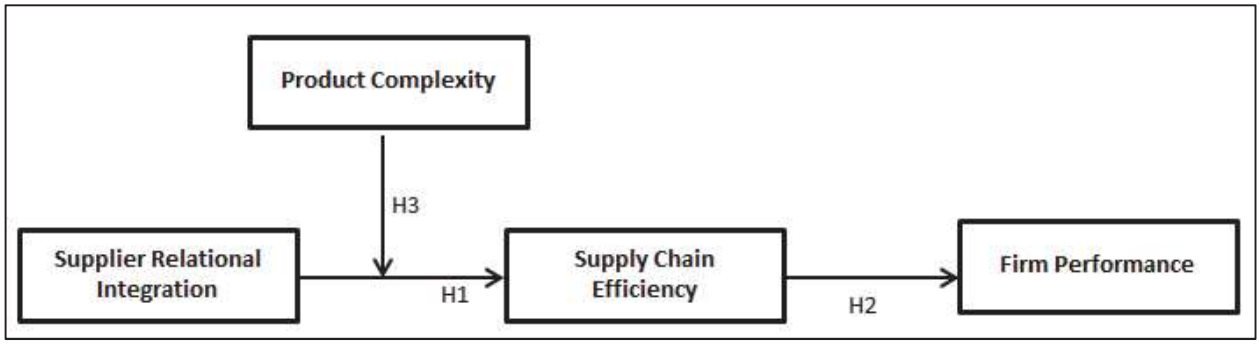
According to Contingency theory, a method or approach may not necessarily be the ideal option under all instances. This suggests that firms should choose their approach by considering appropriate situational variables. Along the same lines, this study proposes examining the benefits of supplier relational integration under conditions of product complexity.

This study and previous studies have examined the benefits of supplier integration on various aspects of performance and the general view is that there are positive impacts on performance. However, we do not have a clear idea as to whether more supplier integration is always beneficial. Anecdotal evidence suggests that the need for integration and benefits of integration increase as the system becomes more complex. This can be explained using Information processing theory. According to this theory, information processing requirements increase with an increase in uncertainty and task complexity (Galbraith, 1974). Under such conditions, inability to effective process information will adversely affect performance. One of the ways to deal with this would be to increase information processing capability by designing programs or by formulating rules to achieve coordination (Galbraith, 1974). Supplier integration and relational integration in particular is proposed to be one such arrangement. In this study, the performance benefits of supplier relational integration are proposed to be greater under conditions of high product complexity. Under conditions of low product complexity, the costs of relational integration may not be adequately offset by the benefits of integration. Also, when product complexity is low, firms might be able to achieve adequate levels of coordination and performance with mere operational integration or through some of their existing mechanisms (eg: contracts, market mechanisms). The benefit-cost ratio might not be attractive enough to go through the hassle of relational integration with suppliers. For low complexity and commodity type of products, companies might prefer the wriggle room that arm's length and open market relationships provide. That would give them the opportunity to negotiate based on price and other factors. Exiting or concluding open market relationships may not be cost prohibitive since these are transactional in nature. Closer relationships (such as relational integration) on the other hand might be expensive to exit partly because of their resource intensive nature. Thus, the positive effect of supplier relational integration on supply chain efficiency is proposed to be more pronounced under higher levels of product complexity.

H3: Product complexity moderates the relationship between Supplier relational integration and Supply chain efficiency.

The proposed relationships are identified in the conceptual model below.

FIGURE 1
CONCEPTUAL MODEL



METHODOLOGY

Measures and Questionnaire Design

The measures for supplier relational integration and product complexity were developed based on review of relevant literature. The measurement items were tested for content validity by consulting with subject matter experts (academics and industry professionals). Content validity determines the extent to which the domain of a concept is captured by the measure (Churchill, 1979). The measurement instruments were then pilot tested using Q-sort methodology and were further refined by modifying and/or deleting items based on the feedback of experts (Moore & Benbasat, 1991). Two rounds of Q-sort were conducted. The measures for supply chain efficiency and firm performance were adopted from previous studies (Fisher, 1997; Vonderembse et.al., 2006; Shah and Ward, 2003; Li et.al., 2005; Li et.al., 2006; Koufteros, 1995; Koufteros et.al., 1997; Krause et.al., 2007). An online questionnaire was designed with the indicators being measured on a five-point likert scale (1 = strongly disagree and 5 = strongly agree). See Appendix A for the construct measures.

Sampling and Data Collection

Data was collected from a survey of manufacturing companies in USA. To obtain a representative sample, prospective respondents were randomly selected from the Lexis Nexis Academic database. Prospective respondents included professionals in managerial roles in the areas of purchasing, supply chain, manufacturing and operations. Some of the job titles considered acceptable for this study were purchasing manager, supply chain manager, purchasing director, VP of manufacturing, VP of Purchasing, VP of supply chain, VP of operations, CEO and President. The sample was refined based on NAICS codes (31 to 33) and company size (> 100 employees; > $10 million revenue). The sample initially had 5000 names/e-mail addresses, out of which 3023 were invalid. 270 complete responses were received (13.66% response rate). The measures were then tested for convergent validity, reliability and discriminant validity. Exploratory Factor Analysis (EFA) was used initially to assess convergent validity (Hair et.al., 2006; Raubenheimer, 2004). Reliability was evaluated using Cronbach's alpha scores. Confirmatory factor analysis (CFA) was used to test for discriminant validity. Discriminant validity was assessed by evaluating the correlation coefficients of constructs (Hair et.al., 2006). Accordingly, pair-wise comparison of the correlation coefficients to the square root of the average variance extracted (AVE) was conducted. The square root of AVE estimate was found to be greater than the correlation coefficient, which indicates discriminant validity (Fornell and Larcker, 1981; Koufteros, 1999; Koufteros et.al., 2001).

RESULTS

The proposed relationships were tested using AMOS package for Structural Equation Modeling (SEM). The overall model fit of the proposed model was assessed by the following model fit indices – Goodness of Fit (GFI), Adjusted Goodness of Fit (AGFI), Root Mean Square Residual (RMR), Normed Fit Index (NFI) and Comparative Fit Index (CFI). Individual relationships were then examined.

TABLE 1
HYPOTHESES TESTING RESULTS

Hypothesis	Regression Coefficient	t-value	Supported or Not
H 1	0.34	5.89***	Supported
H 2	0.27	9.12***	Supported
H 3	0.02	0.32	Not Supported
GFI = 0.99; AGFI = 0.96; CFI = 0.98; RMR = 0.018; RMSEA = 0.063 *** = p<0.01; **= p<0.05; *= p<0.1			

H1 examines a direct relationship between supplier relational integration and supply chain efficiency. This relationship was supported thus indicating that supplier relational integration is positively associated with supply chain efficiency. This indicates the importance of the three sub-constructs (information sharing, decision synchronization and collective learning) in achieving efficiency in the supply chain. H2 examines the effect of supply chain efficiency on firm performance. The proposed positive relationship was strongly supported indicating that an increase in supply chain efficiency is associated with an increase in firm performance. This reinforces the thought that a firm is only as good as its supply chain. To achieve results at the firm level, it is imperative to have a supply chain that is performing well. H3 examines the moderating effect of product complexity on the relationship between supplier relational integration and supply chain efficiency. The performance impact of supplier relational integration on supply chain efficiency was proposed to be stronger under conditions of higher product complexity. However, the results do not support H3. The lack of support for the moderating relationship was surprising and interesting. A possible explanation for this would be the existence of an indirect effect instead of a direct moderating effect. Complexity of the supply chain or the supply base of the firm thus becomes a variable of interest. It is logical to assume that a complex product will have a complex supply chain. For instance, a car is much more complex than a pencil. Thus, the supply chain of the car manufacturer is bound to be much more complex than the supply chain of the pencil manufacturer. It would hence be interesting to examine the moderating effect of supply chain (or supply base) complexity on the supplier relational integration-supply chain efficiency relationship.

DISCUSSION AND CONCLUSION

The study builds on the conceptualization of the supplier integration construct. Previous studies examine supplier integration primarily from the point of information sharing. This study includes information sharing, decision synchronization and collective learning as the key components of supplier relational integration. It highlights the need to consider actions beyond mere information sharing to achieve better results. Information sharing is just the first step towards achieving integration and true integration calls for synchronized decision making and learning with/from supply chain partners.

Supply chain efficiency is shown to be positively associated with firm performance, which includes both operational and market indicators. This once again emphasizes the importance of viewing actions and relationships from a supply chain perspective. It provides support to the often-used statement that ‘firms no longer compete against each other, rather supply chains do’. A firm’s supply chain can thus make or break a firm.

The lack of support for the moderating relationship was briefly discussed in the previous section. This result sheds light on factors other than product complexity that drive the need for close integration between a firm and its suppliers. Changing dynamics within the supply chain caused by factors such as an increase in number of suppliers, geographic spread of the supply base, operational diversity within the supply base perhaps create the need for close integration between supply chain partners. However, product complexity may in fact influence the structure and nature of the supply base itself. For instance, a complex product with many individual components will result in a large and complex supply base. This is most commonly seen in the automotive industry where car manufacturers at one point struggled with managing large supply chains that were spread across the globe. Manufacturers thus actively embarked on supply base reduction, rationalization and optimization. However, there is a limit to which you can reduce or simplify the supply base. Ultimately it is a question of how you manage the effects of complexity in the supply base. Thus, supply chain/base complexity and the ability (or the lack thereof) to manage this complexity may have a significant role to play as a moderating variable.

This study contributes to theory by developing and validating measures for the three dimensions of supplier relational integration and for the construct of product complexity. These measures could be modified and adopted in other studies. The study thus adds value by building on previous empirical studies. The study builds on previous studies to show the application of information process view in examining the effects of complexity in the supply chain.

In terms of managerial implications, this study can be of relevance to supply chain professionals who are seeking ways to improve the performance of their supply chain. It identifies areas that they could focus on to achieve efficiencies within their supply chain. In the face of increasing levels of product (and supply base) complexity, it might not always be possible to actively reduce complexity levels. An alternative would thus be to achieve integration with supply chain partners which would help manage the effects of complexity. Managers thus would benefit from developing mechanisms for joint decision making and collective learning in their quest for improved performance.

The study is limited by the fact that the data collected was cross-sectional in nature and the study was also limited to the manufacturing industry in the US. Future studies could consider broadening the scope and applicability of the ideas suggested in this study. Single respondent bias is another limitation since the same respondent is asked about both independent and dependent variables. However, the ever-declining survey response rates make it difficult to have multiple respondents from the firm answering different sections of the survey. The absence of measures based on secondary data may be a limiting factor for the study.

Future studies could consider developing measures based on secondary data. Researchers could benefit immensely if one could develop a complexity index based on secondary data for products and supply chains.

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APPENDIX

Construct Measures

Construct	Survey Items	Cronbach Alpha
PRODUCT COMPLEXITY	Our product is composed of a large number of components	.7
	Our product is composed of components that are closely interrelated such that a change in one component results in a change in another component	
	Our product is based on technology that is complex	
	Our product is based on new technology	

Construct	Sub-construct	Survey Items	Cronbach Alpha
SUPPLIER RELATIONAL INTEGRATION	Information Sharing	We share information with supply chain partners regarding ….	.85
		… market trends	
		… changes to supply chain processes	
		… changes in technology	
	Decision Synchronization	We make joint decisions with supply chain partners for …	
		… strategic inventory planning (eg: inventory locations, warehouse locations, distribution centers)	
		… strategic planning of production activities (eg: long-term production and capacity planning)	
		… strategic planning of logistics and distribution	
	Collective Learning	We jointly develop understanding and competencies with supply chain partners for…	
		… strategic planning of new products	
		… strategic planning of production activities	
		… identifying strategic trends in customer requirements	

Construct	Survey Items	Cronbach Alpha
SUPPLY CHAIN EFFICIENCY	Our firm's supply chain is successful in …	.72
	… minimizing overall cost	
	… minimizing inventory levels	
	… providing reliable delivery	
	… meeting quality specifications	

Construct	Sub-construct	Survey Items	Cronbach Alpha
FIRM PERFORMANCE	Operational Performance	Our firm is successful in …	.82
		… offering high quality products to our customers	
		… achieving on-time delivery to customers	
		… responding to changing customer requirements	
	Market Performance	… increasing market share	
		… increasing revenue	
		… increasing Return on Investment (ROI)	
		… increasing Return on Assets (ROA)	