The Impact of Vertical Integration on Inventory Turnover and Operating Performance

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Abstract

This paper investigates how vertical integration may influence inventory turnover and firm operating performance. A causal model is developed to investigate the effects of vertical integration on three types of inventory, namely raw materials inventory (RMI), work in progress inventory (WIPI) and finished goods inventory (FGI). The model tests the interactions between inventory types and the consequences of inventory turnover performance on various aspects of firm performance including costs and profitability. In particular, path analysis supports systematic differences with respect to how vertical integration affects RMI, WIPI and FGI. Vertical integration has a positive effect on RMI and FGI turnover but no significant effect on WIPI turnover. FGI contributes to a reduction in supporting processes costs which causes an improvement in Return on Sales (ROS). Vertical integration impacts ROS directly.

Keywords

1.0 Introduction

One critical operations management challenge faced by firms in manufacturing and distribution is the management of their inventory and importantly the level of inventory turnover. Several models have been developed in the scientific literature to address the challenges posed by inventory including the Economic Order Quantity (EOQ) model, stochastic inventory models, materials requirement planning (MRP) production systems and just-in-time (JIT) environments (see Hopp and Spearman, 1996; Nahmias, 1997). Inventory control problems have also been addressed from a supply chain management perspective focusing on the effective co-ordination of material flows, information flows and financial flows (Buzacott and Zhang, 2004; Cachon and Fisher, 2000; Dong and Xu, 2002; Shah and Shin, 2007).

To alleviate supply chain related problems managers as well as scholars have considered the effects of a vertically integrated organization structure. Vertical integration entails the control of a firm's assets and provision of goods, services or intermediate inputs and outputs in-house. From a practical management perspective, vertical integration has been pursued by companies that have been engaged primarily in exploration and extraction of crude petroleum and decided to acquire downstream refineries and distribution networks. Companies such as Shell and BP came to control every step involved in bringing oil from exploration to the consumers' vicinity in an effort to address supply chain related problems among other goals. In terms of scholarly research, the work of Baker and Hubbard (2003, 2004) and Pirrong (1993) raise the interesting question of whether vertically integrated control structures have a natural advantage in solving complex coordination or matching problems that would include supply chain problems. In addition from an economic perspective both the transaction cost approach (Williamson, 1975, 1985) and the property rights model (Grossman and Hart, 1986) indicate positive performance implications from vertical integration.

Transaction cost theory also suggests that vertical integration should have a positive effect on inventory turnover levels within an organization (D'Aveni and Ravenscraft, 1994). For instance, a higher degree of internal transfers that will occur in a vertically integrated organization will reduce transaction costs and improve information exchange through successive production stages. On this basis vertical integration will also facilitate the internal and external supply chain integration of a firm, i.e. the collaboration among supply chain partners which are internally owned and controlled, thus contributing to more effective and

efficient intra and inter-organizational processes (Zhao et al, 2008; 2011). Vertical transfers will also improve production and inventory scheduling that can substantially reduce a firm's cost by reducing unused capacity and inventory carrying costs (Harrigan, 1983).

According to Frohlich and Westbrook (2001) the essence of supply chain and logistics integration is the well-coordinated flow of materials from suppliers which allow firms to have a smooth production process. This meant that firms needed not only to improve production techniques but to focus on the integration of the supply activity with what customers demand (Frohlich and Westbrook, 2001). The concept of integration extends to the linking of customers as well as suppliers (Calantone et al., 2002). A prime objective of integration is pursuing an information-sharing policy to control supply chain uncertainties arising from variable lead time (Beamon and Chen 2001; Dev, et al, 2013; Hung et al, 2014). The links in a manufacturing firm's value/supply chains is critical if the firm is to deliver superior value to the consumer (Ragatz et al, 2002). Value in the form of on-time delivery, delivery reliability, lead time length and inventory service level are especially critical in today's lean supply chains, where deficient service performance can have consequences that, due for example to low buffer stocks and make-to-order strategies, can propagate to the end-customer (Forslund and Jonsson, 2010). On this basis vertical integration should contribute to better integration and co-ordination in a firm's value (supply) chain and hence an improvement in the co-ordination mechanisms associated with the inbound, operations and outbound processes and not least with the level and cost of inventory as well as with financial performance. Inventories represent a major part of a firm's assets particularly the combination of raw materials inventory (RMI), work in progress inventory (WIPI) and finished goods inventory (FGI). Operations management research has not as yet addressed whether and how vertical integration affects the various dimensions of firm operational, supply chain and operating performance, particularly in the context of the various inventory types that accrue within a manufacturing organization's internal supply chain (Harrigan, 1985; D'Aveni and Ravenscraft, 1994; Leiblein et al, 2002; Li and Tang, 2010).

Even the direct effect of vertical integration on operating performance is ambiguous and requires further empirical investigation and scrutiny. For instance, D'Aveni and Ravenscraft (1994) found that vertically integrated lines of business economized on general and administrative, other selling, advertising and R&D expenditures but had higher production costs, therefore, only marginally contributed to profitability compared to non-integrated firms.

Li and Tang (2010) refer to an inverted U shaped relationship between vertical integration and innovative performance and a diminishing reduction on the impact of the effectiveness of external knowledge sourcing on performance. Jacobides and Hitt (2005) on the other hand suggest that productive capabilities may be leveraged better by using both vertical integration and the non-vertically integrated governance mode and conclude that the distribution of productive capabilities along the value chain, catalyzed by transaction costs, ultimately drives vertical scope.

The aim of this paper is to test an empirical model of the consequences of vertical integration in improving inventory turnover performance across the three types of inventory, namely, RMI, WIPI and FGI. In addition, the paper will test the consequences of inventory turnover performance on various aspects of firm performance including costs and profitability. The study contributes to theoretical knowledge and the extant literature as follows.

First, in a meticulous and exhaustive analysis of the literature dealing with the consequences of vertical integration, Lafontaine and Slade (2007) identify effects of prices, quantities, investment and profits but do not provide evidence of supply chain effects such as inventory performance. Although there are many explanations as to the benefits emanating from vertical integration, the arguments are based on the theory of transaction cost economics used to explain vertical boundary choice (Balakrishnan and Wernerfelt, 1986; McDonald, 1985; Williamson, 1985). For instance, Mahoney (1989; 1992) classifies the motives for vertical integration into transaction costs considerations, strategic considerations such as raising entry barriers, output and /or input price advantages brought about by reduction of the effect of monopolists in the firm's production process and uncertainties/risks in costs and/or prices reduced through vertical financial ownership. There has been less focus on the supply chain performance consequences of vertical integration, an aspect addressed in this paper by focusing on inventory performance. For the first time the effects of vertical integration are examined in relation to the internal supply chain process of firms which includes the inbound, work in progress and outbound inventory performance as well as the supporting processes. Capkun et al (2009) examined the relationship between the discrete types of inventory and gross and operating profitability. Eroglu and Hofer (2011a) find a concave relationship between inventory leanness and firm performance. We add to this literature by examining also the effects of vertical integration on RMI, WIPI, FGI and firm operating performance.

Second, previous research, particularly in the operations management and supply chain literature, focused on explaining the effects of integration between supply chain partners on the basis of vertical integration effected via contractual and inter-organizational relationships (e.g. Das et al, 2006; Goffin et al., 2006; Chan and Prakash, 2012). It has been long acknowledged however, that contractual and inter-organizational relationships are susceptible to market failures (Williamson, 1971) whereas vertical integration poses possible advantages (Harrigan, 1985). This study makes a contribution by investigating the supply chain performance effects of firms that are vertically integrated in the supply chain process through the full financial ownership of other firms than mere outsourcing relations or quasi-vertical integration.

Third, the study contributes to the literature examining the relationship between vertical integration and firm performance which arguably posits mixed results. For instance, Reed and Fronmueller (1990) reject the hypothesis of possible performance differentials between vertically integrated and non-integrated entities. They state that vertical integration (via whole ownership) is performance and risk-neutral suggesting that successful strategy selection and subsequent performance is a function of firm-specific competencies and opportunities. Bhuyan (2002) reveals the existence of a negative relationship between vertical integration and profitability. According to this study of vertical mergers in US food manufacturing firms, the negative impact on firm profitability arises because vertical integration fails to create differential advantages such as cost savings for the integrated firm. On the other hand, D'Aveni and Ravenscraft (1994) find net benefits and operational advantages from vertical integration arising from lower general, selling and administrative costs and lower R&D expenditures. Our study contributes to this stream of literature by recognizing the different characteristics and possible differential effects in the interactions between vertical integration and the three recognized and distinct types of inventory performance. This is achieved by empirically testing a causal model using path analysis.

The paper is structured as follows. Section 2 reviews the relevant theoretical background on vertical integration and inventory turnover performance, which represent the central concepts of the study. Section 3 develops the research hypotheses. Section 4 presents the methodology adopted to facilitate the empirical examination of the research hypotheses. Section 5 discusses the results of the study. The paper concludes with a summary of the study's results and reference to the limitations and future research prospects in section 6.

2. Theoretical framework

2.1 Vertical integration

The theoretical literature treats vertical integration in relation to the decision by corporations to provide certain goods, services or intermediate inputs and outputs in-house or purchase them from outsiders instead (e.g. Harrigan, 1985). This can be manifested either through vertical financial ownership and complete control over assets achieved through merger, acquisition or internal development extending company boundaries or through vertical contracting which includes exclusive dealing, resale price maintenance and exclusive territories (Mahoney, 1992). Regarding the latter, Blois (1972) used the term 'vertical quasi-integration' to define financial relationships between firms in neighboring stages. These relationships need not involve additional control of production and distribution decisions such as equity investment, loans or loan guarantees, leases on real estate or capital and inventory credits. However, most theories of vertical financial ownership are more accurately described as theories of vertical integration strategy (Mahoney, 1992). As stated by Maddigan (1981) vertical integration describes the firm's strategy of exercising ownership control in the production of products that are used as inputs to each other and thus, it is much more than the joining or contractual integration of production processes. Vertical integration can also be described as the overall scope of different business activities in a supply chain brought under the management of a single company (Majumdar and Ramaswamy, 1994). It is distinct from supply chain integration which has been described as the integration of all value-adding activities and business processes from raw material extraction to the consumption of products by end users (e.g. Cousins and Menguc, 2006; Frohlich and Westbrook, 2001; Narasimhan and Kim, 2002).

Perry (1989) describes a vertically integrated firm as one that encompasses two single-output production processes in which either (1) the entire output of the "upstream" process is employed as part or all of the quantity of one intermediate input into the "downstream" process or (2) the entire quantity of one intermediate output into the "downstream" process is obtained from part or all of the output of the "upstream" process. Harrigan (1986) on a similar premise defines vertical integration in relation to the requirements for a particular resource that a business unit obtains from an upstream sister business unit or the outputs that a business unit sells to (or through) a downstream sister unit. Perry (1989) suggests that 'partial' vertical

integration would exist in the case where most (and not all) of the output of the upstream process is employed as most of the input in the downstream process.

The paper adopts the definition provided by Grossman and Hart (1986) who argued that vertical integration is the ownership and thus complete control over 'assets'. They assert that the nature of the firm's relationship with labor, as discussed by Williamson (1975) and Cheung (1983) is not relevant for distinguishing vertical integration. Inherent in this definition of vertical integration is the elimination of contractual or market exchanges with the vertically integrated organizations, and the substitution of internal exchanges within the boundaries of the firm.

2.2 Inventory

Inventory represents a portion of a firm's assets. Inventory serves specific purposes that bring certain advantages for a firm (see Stock and Lambert, 2001 for an analysis of the advantages of holding inventory). However, since the early 1980s, the inventory literature has treated inventory as a waste that should be minimized (e.g. Hall, 1983; Schmenner and Swink, 1988). Inventory reduction has been the target for various operations management approaches including lean production (Chen et al, 2005), just-in-time (Huson and Nanda, 1995) and total quality management (Flynn et al., 1995).

The literature (e.g. Eroglu and Hofer, 2011a) recognizes three types of inventory namely, raw materials inventory (RMI), work in progress inventory (WIPI) and finished goods inventory (FGI). It has been recognized however, that most studies have focused almost exclusively on FGI despite the widely acknowledged significant differences in the behaviors of RMI, WIPI and FGI (Chican, 1996; Eroglu and Hofer, 2011a; Holly and Turner, 2001; Sensier, 2003; Tsoukalas, 2006). Humphreys et al (2001) and Eroglu and Hofer (2011b) view the failure to recognize interactions among inventories in different stages of manufacturing (RMI, WIPI, FGI) as a major theoretical and empirical weakness in economic research that attempts to explain the behavior of profit-maximizing firms. Chen et al (2005) identified that RMI, WIPI and FGI of US companies have changed at different rates during the period of 1981-2005, suggesting that there are differential effects and possible interaction effects between the three types of inventory.

The management of inventory internally, achieved via a vertically-integrated structure, may have implications for the total cost of inventory management and firm performance. For example, Dong and Xu (2002) found vendor managed inventory (VMI) to reduce total costs of the channel system. A typical VMI program involves a supplier which monitors inventory levels at its customer's warehouses and assumes inventory management responsibilities; in effect what is achieved through a vertically integrated structure. According to the authors anecdotal evidence suggests that a consignee may enjoy reductions in holding costs and some operational costs plus cash flow benefits. In addition, inventory inaccuracy which may arise due to information distortion in the supply chain arising from misalignment between physical and information flows will lead to increase in costs and the reduction of supply chain performance (Fleisch and Tellkamp, 2005).

3. Hypothesis development

According to Klein (1988), by shifting the ownership of an organizational asset, vertical integration can imply an increased ability to direct cooperating inputs compared to a long-term contractual arrangement. There is an existing set of theoretical literature that focuses on the consequences of vertical integration. Vertical integration, can enhance performance through the coordination mechanisms associated with internalization and reduction in transaction costs and market exchanges (Williamson 1975), exploiting opportunities for coordinating internal activities, (Harrigan, 1983; Hennart, 1988) creating power over buyers and suppliers (Vickers and Waterson, 1991), the development of firm specific capabilities over time (Novak and Stern, 2008) and the development of knowledge (Kogut and Zander, 1992; Grant, 1996; Nickerson and Zenger, 2004). These perspectives form a theoretical basis for the conceptual relationship between vertical integration, inventory turnover and operating performance.

3.1 Vertical integration and inventory management

On the basis of the transaction cost approach, vertical integration may confer inventory turnover improvement chiefly because of the coordination benefits associated with internalization. Increased coordinative abilities may be due to either an improved flow of administrative information or due to technological interdependencies that exist between activity stages and specifically in the process of inbound and outbound transfer of raw materials and finished goods respectively as well as during the process of manufacturing (work in progress inventory). This perspective is supported by research which suggests that

locating manufacturing activities outside of the firm's boundaries can degrade a firm's capabilities by impairing cross-functional coordination (e.g. Allen, Lee, and Tushman, 1980; Chesbrough and Teece, 1996; Griffin and Hauser, 1992; Hatch and Mowery, 1998; Teece, 1996). Harrigan (1983) indicates that extensive internal vertical transfers and coordination in production and inventory scheduling can substantially reduce unused capacity and inventory carrying costs. Central in inventory management is communication efficiency between supply chain partners. An advantage of vertically integrated firms is the development of a coding system which increases communication efficiencies and provides stability in operations (Arrow, 1975; Mahoney, 1992; Malmgren, 1961). The literature does not however, provide unequivocal evidence on the impact of vertical integration on the various components of inventory turnover namely, raw materials inventory turnover (RMIT), work in progress inventory turnover (WIPIT) and finished goods inventory turnover (FGIT).

On the basis of the above it is hypothesized that:

$H_{1(a)}$: *Vertical integration will be associated with increased raw materials inventory turnover levels.*

$H_{1(b)}$: *Vertical integration will be associated with increased work in progress inventory turnover levels.*

$H_{1(c)}$: *Vertical integration will be associated with increased finished goods inventory turnover levels.*

In addition to the above, and based on the work of Chen et al (2005), Chican (1996) and Eroglu and Hofer (2011a), improved inventory turnover levels are hypothesized to have causal influences between each other. For instance, improved RMIT may contribute to an improvement in WIPIT and FGIT. WIPIT may also impact on FGIT. On this basis:

$H_{2(a)}$: *Improved raw materials inventory turnover will lead to improved work in progress inventory turnover.*

$H_{2(b)}$: *Improved raw materials inventory turnover will lead to improved finished goods inventory turnover.*

$H_{2(c)}$: *Improved work in progress inventory turnover will lead to improved finished goods inventory turnover*

3.2 Inventory turnover and firm performance

The inventory management literature recognized the significant positive impact of good inventory management on firm performance (Capkun et al., 2009; Eroglu and Hofer, 2011a). However, most previous research focused either on total inventory performance (Gaur et al, 2005) or exclusively on finished goods inventory (e.g. Blinder and Maccini, 1991; Cachon and Olivares, 2010). D'Aveni and Ravenscraft (1994) suggest that transaction costs such as selling and advertising expenses may be eliminated because product information is transferred through internal hierarchies and order taking is also handled administratively rather than through exchange in the open market. Support activities in the value chain are impacted by supply chain management systems according to Dehning et al (2007). Hence, improved inventory management performance (measured by inventory turnover) is bound to produce cost savings across the value chain.

Among the studies that have distinguished between the three types of inventory, Lieberman et al (1999) use survey data on several hundred automotive suppliers in North America to evaluate the determinants of inventory levels in high-volume discrete parts manufacturing. They assess the magnitude of raw materials, work-in-progress, and finished goods inventories held at automotive supply plants and conclude that each type of inventory is driven by very different factors. Safizadeh and Ritzman (1997) find that the effects of manufacturing process choice vary across RMI, WIPI and FGI. Dehning et al (2007) examine the financial benefits of information technology investments around newly adopted IT-based supply chain management (SCM) systems and found that the adoption of SCM affects differentially RMI, WIPI and FGI. They find that SCM systems increase gross margin, inventory turnover, market share, return on sales, and reduce selling, general, and administrative expenses.

Capkun et al (2009) test the relationship between both inventory performance and the discrete types of inventory (RMI, WIPI, and FGI) and the profitability of operations, both at the gross and at the operating profit levels. The paper finds a significant positive correlation between inventory performance (total as well as the discrete components of inventory) and measures of financial performance (at both the gross and operating levels) for firms in manufacturing industries. The correlation between the performance of discrete types of inventory and financial performance varies significantly across inventory types. RMI performance has the highest correlation with all financial performance measures (earnings before interest and taxes and gross profit margins). Between WIPI and FGI performance, the former is more highly

correlated with gross profit margins while FGI is more highly correlated with operating profit measures.

Eroglu and Hofer (2011a) test empirically the performance effects of raw materials, work-in-progress and finished goods inventories using data from US manufacturing industries. Their study identifies differential effects between the three types of inventory. Specifically raw materials inventories were found to have greater impact on firm performance than work in progress and finished goods inventories. The suggested reason is the possible asymmetrical effects of raw materials and finished goods inventories on each other over time.

The above lead to the following research hypotheses:

$H_{3(a)}$: High RMIT levels will reduce the costs associated with supporting processes in a firm's internal supply chain.

$H_{3(b)}$: High WIPIT levels will reduce the costs associated with supporting processes in a firm's internal supply chain.

$H_{3(c)}$: High FGIT levels will reduce the costs associated with supporting processes in a firm's internal supply chain.

It is also expected that a reduction in the costs associated with supporting processes in a firm's internal supply chain will contribute to an improvement in financial performance. For instance, it is interpreted in fundamental analysis that an increase in selling, goods and administrative costs (margin) is a negative signal to future profitability and firm value (Anderson et al, 2007). On this basis:

H_4: The level of supporting costs in a firm's internal supply chain will be inversely related to a firm's operating performance.

3.3 Vertical integration and performance

The literature suggests that vertical integration can also have a direct effect on firm performance. For instance, vertical integration can increase profits through higher prices by creating barriers to entry (Bain, 1956; Salop and Scheffman, 1983), allowing price discrimination (Perry 1980), reducing service and advertising externalities (Jones and Hill, 1988) or providing a firm with power over buyers or suppliers (Porter, 1980). Costs may also be decreased by avoiding market costs (Jones and Hill, 1988), by reducing transaction costs (Mahoney, 1992) by decreasing uncertainty or asymmetric information resulting in a more

efficient use of inputs (Riordan and Sappington, 1987) and by protecting proprietary technology (Jones and Hill, 1988).

The theoretical evidence is centered on the transaction cost economics approach (Williamson, 1975) and indicates that the decision to use vertical integration depends on the relative monitoring costs that arise from bounded rationality and from uncertainty due to partners' self interest and opportunism (Kaufman et al, 2000). Despite the theoretical arguments, the empirical literature has not established in absolute terms the relationship between vertical integration and performance.

According to Mahoney (1992) the transaction cost approach suggests that vertical financial ownership may most effectively achieve the profit inventive since preemptive claims on profits between separate firms are eliminated. D'Aveni and Ravenscraft (1994) found that vertical integration results in economies even after industry effects and economies of scale and scope are controlled. They posit that vertically integrated lines of business economized on general and administrative other selling, advertising and R&D expenditures. However, they had only marginally higher profitability than non-integrated lines of business due to higher production costs. In addition, they found that forward vertical integration was associated with lower transaction costs. Rothaermel et al (2006) found that vertical integration has an increasingly positive effect on firm performance. The positive effect on performance is likely to be due to the reduction in transaction costs by internalizing the value chain activities.

On the basis of the above we expect in the context of our conceptual model a positive relation between vertical integration and firm performance. This hypothesis serves to test the direct effect of vertical integration on operating performance vis-à-vis the impact of vertical integration via improved inventory turnover and the reduction of process supporting costs. Hence:

H_5: Vertically integrated firms will be associated with improved overall financial performance in relation to non-vertically integrated firms.

4. Methodology

The hypotheses presented entail the simultaneous examination of causal relationships between the variables. Structural equation modeling (SEM) is an appropriate methodology for capturing such relationships between variables because it is concerned with estimating the

magnitude of the linkages between variables and using these estimates to provide information about underlying causal processes (Bollen, 1989). Where only single indicators for each of the variables in the model are available then path analysis which is a special case of SEM is deployed. Path analysis is particularly suited to operations management research (Anderson et al, 1995; Paiva et al, 2008; Swamidass and Newell, 1987). Mathematically path analysis decomposes the empirical correlations among the measured variables to estimate the path coefficients in the path diagram. On this basis path analysis was used to estimate the empirical model. Data was fitted using the SEM library in STATA, with the Maximum Likelihood (ML) estimation method. Missing data were addressed using listwise deletion and the models were fitted in the raw dataset. Raw data were used in order to report robust standard errors allowing for clustering on raw data.

4.1 Sample

Manufacturing companies were chosen for sampling purposes because these are firms with inbound and outbound supply chain processes and hence can adequately measure the changes in the turnover performance of raw materials, work and in progress and finished goods inventory in their internal supply chain. An important part of the sample selection process was the identification of vertically integrated organizations vis-à-vis non-vertically integrated organizations. For the selection process we adopted the definition of between-stages vertical integration and the method suggested and applied by Davis and Duhaime (1992). In particular they posit that vertical integration that occurs between stages in the valued-added chain such as between mining and manufacturing or manufacturing and distribution can be identified using standard industry classification (SIC) codes.

Following Davis and Duhaime (1992), vertically integrated firms are classified using industry segment data from the Compustat database. In particular, for each year primary and secondary standard industry classification (SIC) codes are compared. When either the primary or the secondary SIC codes belong to different value added stages (raw materials, manufacturing, or services) while the other SIC code belongs to one of the other two stages, it is regarded as an indication that a firm is vertically integrated.

The sample consisted of 2,193 firms (or 10,771 firm year observations) that operate in the manufacturing services industry (SIC codes 2000-3999) during the period 1986-2010. We ended up with this sample after listwise deletion of missing observations (considered missing

completely at random after testing for omission bias). Of the 10,771 observations, 5743 or 53.32% are vertically integrated while the remaining 5028 or 46.68% are non-vertically integrated firms.

In order to verify that the chosen companies were vertically integrated, we randomly selected a sample of companies and investigated their vertical integration structure in more depth. Companies Royal Dutch Shell, Petrochina Co Ltd and Shell Transport and Trading have operations classified in SIC 2911 Petroleum Refining and SIC 5172 Wholesale Petroleum and Petroleum Products (no bulk stations). Similarly, Shell Oil Co operates in SIC 2911 Petroleum Refining and SIC 5171 Wholesale Petroleum Bulk Stations and Terminals. It is evident that the above companies are vertically integrated with operations in the extraction of commodities and subsequently their trading in a supply chain adjacent SIC. Similarly companies Texaco Inc., Amoco Co. and Marathon Oil Corp. are vertically integrated with operations in SIC 1311 Crude Petroleum and Natural Gas and SIC 2911. Kubota Corp. is classified in SIC 3321 Iron and Steel Foundries and SIC 1623 Water, Sewer Pipeline, Communication and Power Lines Construction. The company is vertically integrated as it uses the raw materials from its operations in steel foundries to develop and install pipelines and power lines in its second industry sector. Similarly Chrysler operates in SIC 3712 Motor Vehicles, and Passenger Car Bodies and SIC 5012 Wholesale Motor Vehicles and Motor Vehicles Parts and Supplies. Baxter International is classified in SIC 3841 Surgical and Medical Instruments and Apparatus and in SIC 5122 Wholesale Drugs, Proprieties & Druggists' Sundries. The analysis of the companies provides strong qualitative evidence of their vertically integrated structure as they operate in industry sectors that are considered to be adjacent in a supply chain context.

4.2 Measures

Inventory performance has been measured using a variety of ratios in operations management research. They include absolute measures such as average inventory levels and maximum inventory levels (King and Lenox, 2011) standardized measures such as inventory turnover (Schonberger, 2007; Gaur et al, 2005), days of supply (Koumounakos, 2008) and inventory to sales ratios (Swamidass, 2007). The most widely used measures are inventory to sales ratio, inventory to assets ratio, and inventory turnover (White et al, 1999; Chen et al, 2005). Shah and Shin (2007) use inventory to sales ratio because they find that the three measures are highly correlated and the relative amount of inventory used to achieve a certain sales volume

represents a sector's overall efficiency in inventory management. The current study aims to measure independently the three inventory turnover measures namely, RMI, WIPI and FGI. Eroglu and Hofer (2011a) develop an inventory leanness indicator which measures the relationship between sales and inventories in multiple stocking locations of a firm thereby identifying economies of scale in inventory holding. The indicator is used by Eroglu and Hofer (2011b) to measure the three respective types of inventory i.e. an inventory leanness indicator for RMI, WIPI and FGI respectively. The inventory turnover measures used in our analysis were pre-selected based on the Dehning et al (2007) value chain model and in accord to previous empirical studies (Spekman et al., 1994; Fisher, 1997; Elmuti, 2002; Hult et al., 2000; Wisner and Tan, 2000; Chan et al., 2003; Hendricks and Singhal, 2003). In particular, RMIT was measured as cost of goods sold/RMI, WIPIT as cost of goods sold/WIPI, FGIT as cost of goods sold/FGI. The cost of goods sold consists of raw materials, direct labour and overheads. The ratio measures the ability to turn over inventory in relation to cost.

As a measure of supporting costs associated with an improvement in inventory management, we use selling, good and administrative expenses (SGA). The measure was used by Dehning et al (2007) to measure cost savings in administrative accounts across the value chain which are more readily observed in lower discretionary expenses such as selling, general and administrative expenses (Kalwani and Narayandas, 1995). Finally, we used return on sales (ROS) measured as income before extraordinary items/net sales as a holistic measure of firm performance (Byrd and Davidson, 2003; Tan et al., 1999; Vickery et al., 2003). Compustat data were used for deriving all performance measures. Each variable was Winsorized at +-3 standard deviations from the mean (1% level) to control for any potential outliers.

4.3 Control variables

In addition to examining the hypothesized effects, we control for three variables that may impact the performance of a firm. First we control for the size of the firm using the natural log of total assets of the firm. Larger firms may have access to more resources and are consequently able to achieve scale economies (Pfeffer and Salancik, 1978). Second we use the market to book ratio to control for investment and growth opportunities for the firms that are bound to affect firm performance. Market to book ratio measures the relative value of a company compared to its stock price and a low value indicates investment opportunities. Last we use technological intensity measured by R&D expenditure to control for higher performance of advanced technology firms.

5. Analysis of Results

5.1 Assessing model fit

Table 1 in the appendix shows the correlation matrix with descriptive statistics (means and standard deviations) of the variables.

We fitted the model described in the methodology section. Table 2 presents this model along with the respective fit statistics. Since the model was constructed a priori, the primary concern is in the model fit. Although individual p-values for the coefficient estimates are generally considered to be valid taking them into account and investigating potential improvements in the model by removing causal relations falls within the realm of exploratory analysis. Therefore only the fit of the hypothesized model was considered and evaluated using the Chi-squared statistic, the Root Mean Squared Error of Approximation (RMSEA), the Standardized Root Mean Squared Residual (SRMSR), the Comparative Fit Index (CFI) and the Tucker Lewis Index (TLI).

The chi-squared statistic had 29 degrees of freedom and yielded a value of 280.752; this meant that the chi-squared test was highly significant (p-value<0.0001) suggesting a poor fit to the data. However the chi-square test is known to be biased for large sample sizes and will reject valid models (Bagozzi and Yi, 1988). In line with common practice we relied on other indices to assess model fit. The RMSEA statistic yielded a value of 0.028 with a 90% confidence interval of 0.025 to 0.031. This indicates that with 90% confidence the RMSEA statistic is below the desired threshold of 0.05 suggesting a good fit to the data. The SRMR statistic has a value of 0.033 which is also below the desired threshold of 0.05 suggesting a good fit to the data. The CFI and the TLI statistics yielded values of 0.985 and 0.982 respectively which were above the desired threshold of 0.9 also suggesting a good fit to the data. All of these indices met or exceeded the critical values for good model fit (Hulland et al, 1996) hence providing evidence of good model fit to the data.

5.2 Estimation of path model
Table 2 presents the results of the path analysis.
Table 2: Path analysis results.

Variables	Hypothesis	Prediction	Coefficient estimate	S.E.	Z-value	p-value
VI→RMIT	$H_{1(a)}$	+	0.015***	0.008	1.89	0.058
VI→WIPIT	$H_{1(b)}$	+	0.007	0.012	0.56	0.574
VI→FGIT	$H_{1(c)}$	+	0.022**	0.01	2.24	0.025

RMIT→WIPIT	H2(a)	+	0.018*	0.008	2.33	0.02
RMIT→FGIT	H2(b)	+	0.002	0.002	0.88	0.379
WIPIT→FGIT	H2(c)	+	0.002	0.002	1.01	0.311
RMIT→SGA Margin	H3(a)	-	-0.001	0.01	-0.09	0.931
WIPT→SGA Margin	H3(b)	-	-0.008	0.01	-0.79	0.432
FGIT→SGA Margin	H3(c)	-	-0.015**	-0.015	-3.3	0.004
SGA Margin→ROS	H4	-	-0.88*	0.029	-30.24	0
VI→ROS	H5	+	0.036*	0.006	5.6	0

- Results are standardized and standard errors are robust adjusting for company clustering effects.
*Indicates statistical significance at a 1% significance level
**Indicates statistical significance at a 5% significance level
*** Indicates statistical significance at a 10% significance level

Figure 1 shows the path diagram of the model along with the coefficient estimates. The model fit also appears to be in favour of the research hypotheses as follows. The standardized paths from vertical integration to RMIT, WIPIT and FGIT suggest a positive impact of vertical integration on the two types of inventory turnover. However the effect on FGIT is significant at the 5% significance level (0.022, $p < 0.05$), the effect on RMIT is significant at the 10% significance level i.e. denotes a weaker significance (0.015; $p < 0.1$) and the effect on WIPIT is not significant. The results provide support to hypotheses H1(a) and H1(c) and does not support H1(b) which predicts a positive effect of vertical integration on WIPIT.

Vertical integration is found to have an indirect effect on WIPIT via RMIT. The results indicate a statistically significant effect of vertical integration on RMIT (0.015; $p < 0.1$) and a positive and statistically significant relationship between RMIT and WIPIT (0.018; $p < 0.05$). As expected RMIT, WIPIT and FGIT all have negative impact on value chain supporting process costs although only the effect of FGIT is considered to be statistically significant. Hence, only hypothesis H3(c) receives strong support suggesting that individually the three inventory turnover types do not exert a significant effect on the reduction of selling, general and administrative costs. However, FGIT is found to have such an effect.

SGA margin has a highly significant negative effect on the firms' ROS (-0.880; p< 0.01). This provides support to hypothesis H4 which indicates that a higher SGA margin will have a negative impact on a firm's ROS.

Finally, the path coefficient from vertical integration to ROS is significant (0.036; p <0.01 level) supporting hypothesis H5 which indicates that vertical integration has a direct positive impact on the financial performance of a firm.

These results are mostly explained by the correlations between the measures discussed in the previous section with the exceptions being the relations between ROS and high technology companies (Technology Company) and ROS and the Market to Book ratio. Based on the correlation structure of the data, Technology Company and the Market to Book ratio appear to be negatively related to ROS (the correlations were not statistically significant) but in the model their effect appears to be positive. These differences between the model and the correlation structure may suggest that the control variables choice of the model was correct, since omitting them might have overestimated or underestimated the effect of the other coefficients (paths) to ROS. However it has to be stressed that the correlation estimate between Technology Company and ROS was an inadequate estimate of their relationship and a more appropriate statistic is the corrected Kendalls's tau-b statistic which indicated a positive statistically significant relationship between the two. The sign of the control variables is consistent with prior literature.

Overall, the hypothesized model provides evidence that vertical integration affects positively a firm's financial performance directly and indirectly by improving a firm's inventory turnover performance and reducing supporting costs in a firm's internal supply chain.

Figure 1: Model path diagram with coefficients.
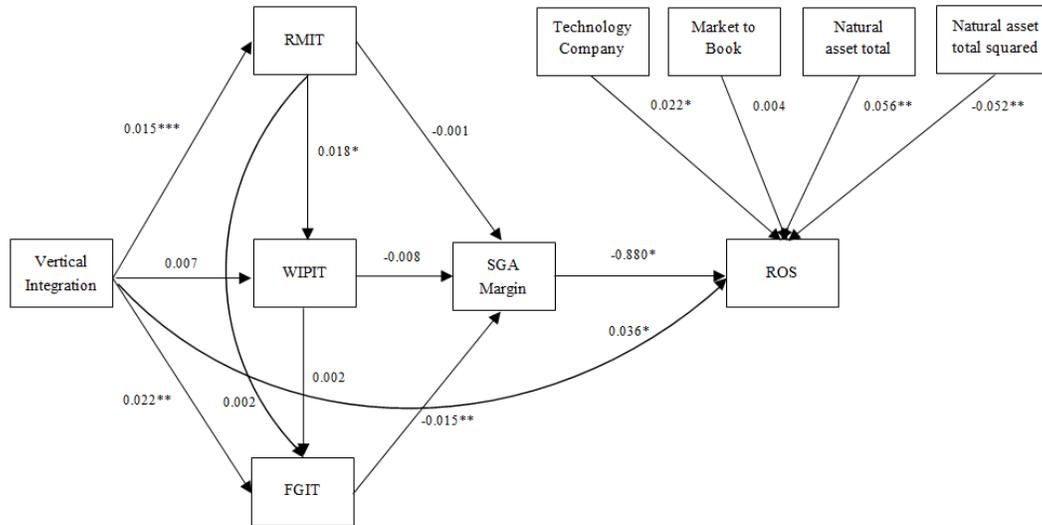
*Indicates statistical significance at a 1% significance level
**Indicates statistical significance at a 5% significance level
*** Indicates statistical significance at a 10% significance level

6. Discussion

The study has tested a causal model and respective hypotheses conceptualizing the effect of vertical integration in a sample of manufacturing companies on the three respective types of inventory turnover and the consequent effects on operational value chain supporting costs and the financial performance of the firm. The results of this study support the notion that there are systematic differences among RMIT, WIPIT and FGIT with respect to how they are influenced by vertical integration as well as their impacts on specific operational and firm performance measures.

The study finds that vertical integration is associated with increased raw materials inventory turnover levels supporting hypothesis H_{1a}. The significant relationship found is justified because having raw materials is extremely important to an internal supply chain of a manufacturing organization. Storing raw materials internally (effected through backward vertical integration) reduces the dependency on suppliers and the risk of intentional (opportunistic) or even unintentional disruptions in supply. First, internalizing raw materials inventory may reduce delays associated with asymmetries (business and/or informational) that may occur during an outsourcing relationship with suppliers. Second, supply risk is minimized as this is a deterrent to opportunism. Third, raw materials may be placed in

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production more efficiently when dependence on outside suppliers is eliminated. Emery and Marques (2011) found that storing raw materials by customers of the raw materials suppliers reduces the transaction costs (including opportunism) and improves the overall effectiveness of managing external supply chain costs.

The findings of this study provide support to the strong relationship between vertical integration and FGIT reached by Cachon and Olivares (2010). Cachon and Olivares (2010) found that the substantial and persistent differences in finished goods inventory performance between Toyota and Chrysler is due to a manufacturing advantage (production flexibility) and upstream supply chain management at Toyota that extends to their finished-goods supply chain downstream from their assembly plants to their dealerships. We assert that vertical integration improves upstream supply chain management as documented by various studies pointing to the increase of supply chain disruptions due to outsourcing (Craighead et al, 2007; Hendricks et al, 2009; Kleindorfer and Saad, 2005).

No significant effect is found between vertical integration and WIPIT levels (H_{1b}). This may be attributed to the fact that forward vertical integration can contribute to greater efficiency in the delivery of finished goods downstream in the supply chain. Lieberman et al (1999) find that maintaining communication with suppliers and customers leads to reductions in RMI and FGI with no impact on WIP inventory. As Balakrishnan et al (1996, p. 195) argue, reducing WIP inventory requires less coordination with a firm's suppliers or customers than is required to reduce RMI or FGI and thus impose fewer implementation costs. In addition, that unlike RMI, reducing WIP does not require supply chain stability. Vertical integration is found to affect the three types of inventory performance differentially. This supports the argument by Dehning et al (2007) who document how the adoption of supply chain management systems differentially affects RMIT, WIPIT and FGIT. Lieberman and Asaba (1997) report differences regarding inventory performance across the supply chains of Japanese and US auto manufacturers, although FGI is excluded from the analysis.

Improved RMIT is found to reduce WIPIT (H_{2a}). This finding is supported by the fact that RMIT (i.e. turning raw materials quicker in the internal supply chain) will influence directly internal supply chain functions such as queuing, processing, waiting for batch, moving and waiting to match, discussed as determinants of WIPIT by Hopp and Spearman (2001). RMIT and WIPIT are not found to have any effect on FGIT (H_{2b} and H_{2c}) respectively.

The findings of the study contribute further to our understanding of the interactions between the different types of inventory turnover and their relationship to performance. The findings support and extend previous studies that have found a positive causal effect between total inventories improvement and performance (Fullerton and McWatters, 2001; Fullerton et al, 2003; Huson and Nanda, 1995; Swamidass, 2007). This study contributes to the literature by providing support to the thesis that the different types of inventory have different effects on performance and that the performance effect of FGIT (H3$_c$) is found to be stronger than that of RMIT (H3$_a$) and WIPIT (H3$_b$). This finding can be justified by the fact that RMIT and WIPIT have a lower unit value than FGIT which includes the added value from the manufacturing or conversion process (Hilton, 2009). In addition, customer service and other value chain activities are directly affected by FGI whereas research in pricing indicates that sales prices are a function of the amount of FGI held during and toward the end of the selling season (Smith and Achabal, 1998; Su, 2007). On this basis it is expected that FGIT will have a greater effect on performance and on the costs associated with value chain supporting processes than WIPIT and RMIT. The above is supported by the findings of this study. Also as indicated by Capkun et al (2009) many inventory management initiatives such as just-in-time and setup reduction time have focused on reducing FGIT and WIPIT as opposed to RMIT. Eroglu and Hofer (2011b) despite supporting conceptually and hypothesizing the greater effect of FGIT on performance do not find supporting evidence to their hypothesis. They characterize their findings as intriguing and attribute it to possible inter-temporal interactions between RMIT and other inventory types. Capkun et al (2009) on the other hand found that total inventories and all three types of inventories have a significant effect on firm performance with the stronger effect exhibited by RMIT.

Although H3$_{(a)(b)}$ are not supported with statistical significance the fact that the association between each of the three inventory turnover types and SGA margin is negative is indicative of the direction of this association, i.e. that inventory turnover performance reduces selling general and administrative costs. A significant relationship may be associated with total inventory turnover performance and the SGA margin. In this study we tested the individual effects of the three inventory types which arguably would have a lower effect on reducing the total supporting costs association with selling general and administrative expenses.

The studies by Capkun et al (2009) and Eroglu and Hofer (2011a) have indentified differential effects between inventory types and performance measures but have not crystallized the possible reasons for such effects on the basis of the performance measure used. We find that FGIT has a significant effect on SGA as opposed to RMIT and WIPIT. It is possible that FGIT will have greater effects on costs associated with holding inventory because there is considerably more work associated with holding finished products as opposed to raw materials.

As hypothesized (H4), there is a significant negative relationship between SGA margin and ROS, indicative of the relation between a reduction in SGA margin and the consequent increase in ROS. The results also indicate a positive indirect effect of vertical integration on ROS through the reduction in value chain supporting processes costs (SGA margin).

The last research hypothesis (H5) is derived from the conceptual relationship between vertical integration and performance. This study finds that vertical integration has a positive causal effect on financial performance, i.e. vertically integrated companies have higher financial performance as measured by ROS. Empirical evidence in support of these findings can be traced in a study of vertical integration in the airline industry where Lederman and Forbes (2010) found that vertical integration in airlines is associated with improved operating performance. Novak and Stern (2009) in a study of automobile systems also find that integrated firms have greater improvements in performance over time after vertical integration. This result provides support to the thesis that a high degree of backward vertical integration through internal transfers can create economies by ensuring the adequacy in quality and quantity of supplies as well as reducing cost distortions from monopolized inputs. In addition it provides access to information about input costs and manufacturing process which also contributes towards the achievement of lower costs. Similarly, a high degree of forward vertical integration through internal transfers can reduce costs possibly by guaranteeing adequate outlets for a firm's outputs.

The findings suggest that vertical integration is related to better financial performance, either directly or indirectly through the reduction in FGIT in particular. It also reduces RMIT and indirectly WIPIT.

6.0 Conclusion

The concept of integration is central in supply chain management as evidence by a review of key supply chain process frameworks, such as the supply chain operations reference (SCOR) model and the global supply chain forum (GSCF) framework (Grubic, 2010). This study investigates the effect of vertical integration on various types of inventory turnover in a firm's supply chain and the consequent impact on operational and financial performance for the firm. We find supporting evidence to the hypothesis that vertical integration has a positive effect on raw materials inventory turnover and finished goods inventory turnover but no significant effect on work in progress inventory turnover. FGIT is found to contribute to a reduction in supporting processes costs and in consequence an improvement in ROS. Vertical integration is also found to impact financial performance (ROS) directly.

The results of the study indicate that management must be aware of the power of supply chain integration, including vertical integration in the supply chains, as a means for achieving operational and financial goals. The firm may integrate externally with other firms and internally across functional units to improve inventory levels and generate efficiencies. The results of the study indicate that vertical integration has positive and beneficial impacts on inventory levels which points to the possible positive effects of vertical integration in terms of co-operation, collaboration and co-ordination between upstream and downstream suppliers and distributors. The positive effects of vertical integration may be due to the higher levels of control, co-ordination and integration achieved between previously separated supply chain nodes that came under common control. The internalization of the manufacturer's interactions and exchanges with suppliers, places increased demands for understanding the requirements of distributors, wholesalers and retailers. For the supply chain to function seamlessly and for the benefits of vertical integration to be fully realized it is important that functions related to downstream logistics and marketing are performed efficiently. Hence, the managers of a vertical integrated organization will need to undertake and play a greater role in the influence, control, coordination and integration of downstream supply chain partners. Managers must also be aware of the fact that supply chain integration does not merely impact on inventory levels and operational performance but also influences firm financial performance.

The findings of this study are robust in relation to the methodology used. Obviously the model developed can be refined further by considering different inter-relationships between the key variables as well as various other measures for these variables. The model may benefit from the adoption of a case study approach where the inter-relationships between the

variables may be tested in various settings in specific industrial sectors. For instance, one may specifically examine possible variations in the strength of the relationship between the various types of inventory, vertical integration and performance depending on the industrial sector setting. In addition to the above, the model may benefit by considering other ways of measuring the variables, especially the inventory types where, in the context of a case study, actual levels of inventory may be used. In a case study context, future studies may gather data from the focal firm, its suppliers and customers thus facilitating a more encompassing perspective of the supply chain and aim at analyzing with additional parameters the relationship between inventory performance and financial performance. Another interesting extension of this study would be to collect longitudinal data in order to see the results of vertical integration on the three types of inventory performance and financial performance over time. Lastly, future research may also examine how a focal firm's vertical integration enable it to better respond to a competitor's inventory and supply chain actions.

As with any study of this nature, our research also has certain limitations. First, although inferences are drawn from panel data, there is scope for further research with longitudinal data that can help unearth inter-relationships over time. Second although this paper measures vertical integration, the hypotheses do not distinguish the effects between backward or forward vertical integration. It is possible that backward vertical integration will influence raw materials inventory performance and forward vertical integration finished goods inventory performance. This can be the subject of further empirical investigation. In addition the results are subject to the limitations endogenous in path analysis. Those limitations have been addressed mainly by grounding the hypothesized inter-relationships in the extant literature.

The paper contributes to the literature on vertical integration which suggests varying effects of vertical integration on supply chain and financial performance. In particular the relationship between vertical integration and the possible differential effects on the various components of inventory turnover have not been examined before, despite the recognition that different inventory types may be differentially affected, interact and influence other variables pertaining to the management of the supply chain. The study shows that vertical integration can have beneficial effects on two key inventory types namely, RMI and FGI. This would mean improved inbound and outbound processes for a manufacturing firm as a result of vertical integration. An improvement in finished goods inventory turnover will also reduce

the cost of selling, general and administrative expenses directly and indirectly influence positively the financial performance of the firm.

On the basis of the above future research should aim at differentiating between the three types of inventory and not treat them as a unified entity. The latter would invariably conceal important differences in antecedents and consequences of the components of inventory. The study confirms that inventories play an important role in affecting operational and financial performance of manufacturing firms and an integration strategy via vertical financial ownership would impact the different types of inventory differentially. Hence, firms need to analyze what performance targets they seek with respect to the different inventory components prior to vertical integration.

The empirical estimation of the five research hypotheses and sub-hypotheses provide practical implications for companies assessing the extent to which vertical integration is related to inventory, operational and financial performance. The study finds that only raw materials inventory turnover will have an impact on work in progress inventory. This means that vertically integrated firms will be able to not only turn raw materials quicker but this higher performance will also influence work in progress inventory turnover. This finding re-affirms the importance of treating inventory type performance in isolation as an improvement in one type of inventory performance will influence total inventory performance differentially.

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Table 1: Means, standard deviations and correlations.

	Mean	SD	1	2	3	4	5	6	7	8	9	10
1. Vertical Integration	0.533191	0.49892	1									
2.RMIT	26.5648	261.0958	0.015312	1								
3.WIPIT	163.7816	2718.248	0.006895	0.018823	1							
4.FGIT	42.14561	413.3688	0.021619	0.00237	0.002161	1						
5.ROS	-0.28312	1.443626	0.034039**	-0.00019	0.007634	0.000916	1					
6.Technology Company	0.469687	0.499103	0.050557**	0.018385*	0.024138	-0.00942	-0.00547	1				
7.Mark To Book	3.079772	47.20134	-0.0025	-0.00025	0.003875	0.003604	-0.04002**	-0.00276	1			
8.Natural Asset Total	4.189902	1.939618	-0.03096**	0.026513**	0.03602**	0.003043	0.122664**	0.124068**	0.000834**	1		
9.Natural Asset Total Square	21.31705	18.34347	-0.03349**	0.026306**	0.037209**	-0.00116	0.11618**	0.126018**	0.001144**	0.96057**	1	
10. SGA Margin	0.569741	1.123558	0.00365	-0.00101	-0.00762	-0.01482	-0.88312**	0.033869**	0.049159**	-0.13009**	0.12765**	1

*Indicates statistical significance at a 5% significance level
**Indicates statistical significance at an 1% significance level