EFFECT OF INVENTORY MANAGEMENT EFFICIENCY ON PROFITABILITY: CURRENT EVIDENCE FROM THE U.S. MANUFACTURING INDUSTRY

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ABSTRACT

While manufacturing firms pursue efficient inventory management, there is limited evidence of improved financial performance related to inventory management practices. This paper examines financial statement data for U.S. manufacturing firms to explore the relationship between inventory management efficiency and firm profitability. The results show that a lower ratio of inventory to sales for a firm is associated with higher profit margin for the firm. In addition, small size firms can receive a larger benefit (as measured by profitability) from increased inventory efficiency when compared to medium and large size firms.

Key words: Inventory Management, Profitability, U.S. Manufacturing Industry

INTRODUCTION

Maintaining an appropriate level of inventory is a key issue to firms' operational performance. The supposition is that better inventory management is closely related with firms' better financial performance. Appropriate inventory levels depend on the production schedule as a managerial response to market demand. Inventory is a current asset to a firm, but it is costly to maintain as it waits to be converted into future sales. While excess inventory does increase costs, a shortage of inventory may result in lost sales. Prior research has focused on inventory management methods and optimal inventory sizes as they relate to the balance between more technological information systems, inventory cost savings and production/sales efficiency. Inventory management has evolved into a highly studied and practiced concept in the business world that combines optimizing inventory movement, information-sharing between buyer and seller, lean production strategies, and supply chain management concepts. The core of the current inventory management system is Just-In-Time (JIT) inventory systems.

JIT is a philosophy of management that reduces waste and improves quality in all business process (Harrison and Hoek, 2011). JIT has been applied to many Japanese manufacturing firms since the 1970s (Cheng and Podolsky, 1996). JIT originated from the Toyota production system (TPS) and serves to reduce inventory and lead-time while increasing quality of production. JIT is defined as, "an inventory strategy aimed at improving a business' financial performance by reducing excess inventory and its associated cost" (Sungard, 2007). To implement a JIT inventory system, a sound, long-term relationship with suppliers is critical because suppliers have to fill the inventory as soon as it reaches a minimum level. Therefore, sharing information about the production schedule with part suppliers and delivery companies is essential. This information sharing is now available through a modern IT infrastructure utilizing the Internet and Enterprise Resource Planning (ERP).

ERP was introduced in the 1990s as an enterprise information system designed to integrate production and accounting data and functions across organizations. The main goal of ERP is to share data by all functional departments and to access the data immediately to increase prompt decision making (Motiwalla and Thompson, 2009). Together, the Internet and ERP systems dramatically improve the JIT inventory system, allowing real time information tracking and sharing of both production and accounting information. JIT inventory management and the utilization of Internet and ERP systems provides for a "lean production" opportunity.

The concept of lean production is to minimize inventory and has been widely used since the 1990s (Eroglu and Hofer, 2011). JIT is the heart of the lean production systems. In the late 1990's, the JIT and ERP concepts expanded into a concept known as Supply Chain Management (SCM). The supply chain is defined as "management of network of interconnected business," to satisfy customers' requests (Harland, 1996).

As stated above, the implementation of a technological complete inventory management system to determine an appropriate or optimal inventory level is a critical factor to a firms' financial performance. Better inventory management such as higher inventory turnovers, reduced days-in-inventory, or lower level of inventory-to-sales ratio is closely related with firms' better financial performance (Shah & Shin, 2007). Using data collected from the late 1960's; the late 1990's; and some early 2000's, prior studies investigated the relationship between inventory level and firm's financial performance. A sample of these studies is delineated in our next section of this paper. This prior research offers both numerous and conflicting results as both positive relationships and negative relationships were determined. In addition, inventory management and its impact on financial performance based on firm size was not considered. Because a definitive answer does not exist as to whether optimizing inventory management is related to superior firm financial performance and does the impact differ based on manufacturing firm size, this paper investigates whether successfully managing a low level of inventory will result in higher profitability for the firm. These conflicting relationships and lack of information of the impact on firm size coupled with our utilization of more recent data from U.S. manufacturing firms leads us to a single research hypothesis which states:

Hypothesis: A significant relation exists between firm profitability and inventory management efficiency in U.S. manufacturing industry.

This study begins with a brief literature review followed by data collection methods, research analysis, and a conclusion.

LITERATURE REVIEW

The concept of Supply Chain Management and technologically managing inventory has helped a lot of companies to compete more effectively in their business markets. Kannan and Tan (2004) point out the three popular methods used in order to ensure that the product or service is delivered to the customer in the most efficient way possible. These three methods are JIT, Total Quality Management (TQM), and SCM. All three of these methods go hand in hand because they force the company to eliminate waste while increasing the quality of their products and distribution systems. Their research demonstrates that integrated inventory management methods are correlated with firm financial performance. Using return of assets (ROA) as a measure of financial performance, Kannan and Tan (2004) set out to not only reiterate the impact on firm's operational performance, but also point out that the firm's business performance can benefit from an inventory management system. Their results concluded that integrating a technological inventory management system results in higher ROA.

Shah and Shin (2007) investigate the relationship among IT investment, inventory, and financial performance with industry sector level data of 1960 to 1999. They find that lower inventory levels lead to higher financial performance in manufacturing sector. Their conclusion is that there exists indirect effect on financial performance through inventory management from IT investment. Liberman and Demeester (1999) study Japanese car manufacturers' JIT production with data of late 1960s to early 1990s. They find that there is a causal relationship between work-in-process inventory and firm's productivity, i.e., 10% reduction in inventory leads to 1% increase of labor productivity. Thomas (2002) studies inventory changes and future returns with data from 1970 through 1997. He finds that a firm with inventory increase has experiences higher level of profitability, however, this trend changes immediately with a change of inventory decrease. He finds the negative relationship between inventory level and firm's profitability but he cannot explain the reason. The result from Thomas (2002) conflicts with results from both Liberman and Demeester (1999) and Shah and Shin (2007). Chen, Frank and Wu (2005) investigate inventories of U.S. manufacturing companies in the last two decades of 20th century. They find that firms with high inventory have poor long-term stock returns while firms with slightly lower than average inventory have good stock returns. However, firms with lowest inventory have only normal returns. All four papers study about the relationship with financial performance of U.S. manufacturing industry. But their results are not consistent. The data used in the previous four papers are data of 20th century. Roumiantsev and Netessine (2007) investigated linkage of inventory behavior with financial performance. They found that lower inventory levels are positively associated with return on sales. Capkun et al. (2009) found a significant positive correlation between inventory performance and measures of financial performance in manufacturing companies over 26 year period from 1980 to 2005.

Profitability is a concept that a lot of executives and shareholders put emphasis on. This shows them that their company is operating at a level to where more money is coming in than leaving the company. Gill, Biger, and Muthur (2010) discusses the relationship that occurs between the firm's working capital management and profitability. They define working capital as being involved with current assets and current liabilities while being able to finance these current assets. The main difference between inventory management and working capital management is the fact that working capital management involves managing all of the current assets while inventory management focuses its efforts on inventories alone. Gill et al. (2010) stated that they do not see any relationship between days of accounts payable and profitability or even with days in inventory and profitability. They note that past studies have given results that differ from their own. Given conflicting results in previous studies, we are motivated to offer evidence as to whether inventory management and profitability are related.

DATA

Using the *Compustat* database, the authors obtain annual balance sheet and income statement data for US manufacturing firms. Manufacturing firms are identified in the database by using the NAICS (North America Industry Classification System) code. Manufacturing companies have a NAICS code beginning with 31, 32, and 33. The authors conduct tests on two sets of data: The first data set is made of three years of data from 2005 and 2007, and the second expands the time window to eight years, from 2005 to 2012. Table 1 presents the two data sets.

Table 1
Data Sets

	Data Set I	Data Set II
Periods	2005 ~ 2007 (3 years)	2005 ~ 2012 (8 years)
Number of Firms	1,289	959
Number of Observation	3,867	7,672

The total number of manufacturing companies, which are listed in the U.S. stock markets in 2005 is 1,292. Among them, 1,289 U.S. manufacturing firms are listed for three years from 2005 and 959 firms are listed for eight years. The number of firms decreases in our sample when the sample period is increased to eight years because we use a balanced panel and annual observations for sample firms that are available for all years in the first sample are not available for all firms in the second sample. Data set I ends with fiscal year 2007 in an attempt to avoid our data being influenced by the financial crisis beginning in 2008. During the financial crisis 2008 through 2009, many companies were delisted (Erkens, Hung, and Matos, 2012). To form a balanced panel of data, we require observations for sample firms to occur in all three or eight years and to include all financial statement items so that our final sample includes a total of 1,289 / 959 firms times 3 years / 8 years. Profit margin (PM), calculated as the ratio of net income to total revenue, is used as our measurement of a company's profitability, and inventory-sales-ratio (ISR), calculated as total inventory divided by total revenue, is used to measure inventory management efficiency with a lower ISR being interpreted as a higher level of inventory management efficiency.

ANALYSIS I

This study uses cross-sectional, time-series panel data. Cross-sectional variables are ISR and PM collected for 1,289 U.S. manufacturing companies. The time series for these variables is collected for three consecutive years. The total number of observations is 3,867. We classified these data into three groups based on size of year-firm revenue (table 2): (1) Small size companies with less than or equal to \$100 million dollars per year, (2) medium size company with an annual revenue between \$100 million dollars and \$1 billion dollars, and (3) large size company with greater than or equal to \$1 billion dollars per year. Using this convention, a firm may appear as a different size from one year to the next in our sample. The authors assumed that company's inventory management efficiency depends on the size of the company. The average ISR for the large companies is 0.1265 and those for the medium and small companies are 0.154 and 0.229 respectively.

Table 2
Classification of Company Size and average ISR

Size	Criteria	Number of Observations	Average ISR
Small	≤ \$ 100 M	1030	0.228890
Medium	Between \$100 M and \$ 1 B	1554	0.154085
Large	≥ \$1B	1283	0.126500

Estimating the panel data regression model by ordinary least square (OLS) might provide a biased solution caused by unobserved heterogeneity (Dougherty, 2006). To overcome this possible problem, two approaches were offered: fixed effect and random effect. According to Green (2012), while the fixed effect assumes that individual heterogeneity is correlated with independent variables, the random effect assumes that the individual heterogeneity is uncorrelated with the independent variables. Jerry A. Hausman developed a test for determining which model is appropriate.

To estimate the panel data regression model in this study, the following procedure will be used: (1) Estimate the regression equation with the assumption that intercepts and slope coefficients are constant across time and individual companies, which is called the pooled regression model. (2) Do the Hausman Test to find a better approach between fixed effect model and random effect model. (3) Based on the result in the (2), explore the better model than the pooled regression model.

As we mentioned earlier, we choose ISR as a variable for inventory management efficiency and PM as a variable for company's profitability. In addition, we introduced four dummy variables: two intercept dummies and two slope dummies. The reason for dummy variables is that each size of company may have a different effect on the profitability by inventory management efficiency. To test this relation, the authors estimated the following models:

$$PM_{i,t} = \beta_0 + \beta_1 Large_{i,t} + \beta_2 Medium_{i,t} + \beta_3 ISR_{i,t} + \beta_4 Large_{i,t}*ISR_{i,t} + \beta_5 Medium_{i,t}*ISR_{i,t} + u_{i,t} \quad (1)$$

Where

$Large_{i,t}$ = 1 if the company i belongs to large size company at year t, 0 otherwise

$Medium_{i,t}$ = 1 if the company i belongs to medium size company at year t,0 otherwise

The table 3 presents output from the above regression model by OLS. The F-statistic is 204.7 with a p-value of 2.2e-16. The R^2 is 0.2095.

Table 3
Result from Regression by OLS

	β_i	t-value	p-value	α
Intercept	3.5918	6.296	3.40e-10	0.001
Large	-3.5142	-3.009	0.002637	0.001
Medium	-3.5338	-3.365	0.000774	0.001
ISR	-28.1524	-31.649	< 2e-16	0.001
Large ISR*	28.0762	3.9159	20e-05	0.001
Medium ISR*	27.9826	5.529	2.44e-08	0.001

The regression model (1) needs to be tested for the assumption of homeskedasticity and no serial correlation. To test the homoskedasticity assumption, the Breusch-Pagan (BP) Test was used. The BP Test is supposed to detect heteroskedasticity by running a regression with the squared residuals as a dependent variable. Because the *p-value* (9.98e-11) was less than .01, the null hypothesis of homoscedasticity was rejected with a 1% significance level. Therefore, this data was heteroskedastic. The problem with heteroskedasticity is that the t-statistics of coefficients cannot be trusted because the estimated standard errors are biased. The heteroskedasticity-consistent (HC) standard errors procedure was proposed by Halbert White to fit a model with heteroskedastic residual. This correction procedure for HC standard errors is called White correction. The output from the HC standard errors has the same coefficient with different *t-values* and *p-values* of the coefficients, which are listed in table 4.

Table 4
Result from Regression by HC Standard Errors

	β_i	t-value	p-value	α
Intercept	3.5918	5.059583	0.0e+00	0.001
Large	-3.5142	-4.950047	1.0e-06	0.001
Medium	-3.5338	-4.977455	1.0e-06	0.001
ISR	-28.1524	-4.270610	2.0e-05	0.001
Large ISR*	28.0762	4.258905	2.1e-05	0.001
*Medium * ISR*	27.9826	4.244723	2.2e-05	0.001

To test the autocorrelation, the Durbin-Watson (DW) test was used. The Durbin-Watson (DW) statistic (d) is 1.8968 with a p-value of 0.0005753. The DW d statistic must be compared to two critical d values: d_L and d_H. With six independent variables and 2,000 observations, the 1% one-tailed critical values are d_L = 1.89104 and d_H = 1.90106. If the d is greater than d_H, the null hypothesis, no evidence of positive correlation, cannot be rejected. Variance Inflation Factor (VIF) is a measure of multicollinearity, which is caused by highly correlated independent variables. The suggested cutoff value for VIF is 5.0. The VIF values of five variables (table 5) were between 1.0 and 3.5, i.e. no multicollinearity.

Table 5
Variance Inflation Factor

Large	Medium	ISR	Large*ISR	Medium*ISR
3.996999	3.504987	1.064515	3.427672	2.964264

Result from the Hausman test is 10.1009 chi-square statistic with a p-value of 0.07243, which is greater than the significance level 5%. The Hausman test tells that the null hypothesis of no preference between two models cannot be rejected. Therefore, the random effect model was used. The table 6 presents the output from the random effect model. The F Statistic is 1591.38 with a p-value of 2.22e-16 and the R^2 is 0.67332.

Table 6
Result from Random Effect Model

	β_i	t-value	p-value	α
Intercept	3.41011	6.296	3.40e-10	0.001
Large	-3.68276	-3.009	0.002637	0.001
Medium	-3.26944	-3.365	0.000774	0.01
ISR	-23.9909	-31.649	< 2e-16	0.001
Large ISR*	20.55188	3.9159	20e-05	0.001
*Medium * ISR*	15.70121	5.529	2.44e-08	0.001

Table 7 presents values of intercept and slope for each category. Since values of slope are negative, PM of all three categories rise when ISR goes down. The small size company has the highest intercept value and lowest slope value, which means that the small size company has a greatest effect of ISR on PM among the three categories, indicating all three cases supports the *Hypothesis.*

Table 7 **Intercept and Slope for Each Category**		
	Intercept	Slope
Small Size Company	3.41011 (β_0)	-23.9909 (β_3)
Medium Size Company	0.14067 ($\beta_0+\beta_1$)	-8.28989 ($\beta_3+\beta_4$)
Large Size Company	-0.27265 ($\beta_0+\beta_2$)	-3.43902 ($\beta_3+\beta_5$)

ANALYSIS II

The purpose of analysis II is to add robustness to our result from analysis I by using an expanded time period for our data set and by using a firm's level of assets as a different measure of firm size in order to control for firm profitability that may be related to firm size. To test the relation between profitability and inventory management efficiency, we estimate the following cross-sectional, time series, balanced panel model:

$$PM_{i,t} = \beta_0 + \beta_1 LN(Assets_{i,t}) + \beta_2 ISR_{i,t} + u_{i,t} \quad (2)$$

According to Eriotis, Frangouli, and Ventoura-Neokosmides (2002), we include natural log value of total assets, $LN(Assets_{i,t})$, as a control variable which is firm *i*'s natural log value of total assets in year *t*. The total number of observations in the data set was 7,672, which is data for 959 companies for 8 years from 2005 through 2012. We use the same procedure as we did in the analysis I. The Breusch-Pagan (BP) test is used to test the homoskedasticity and DW test is used to check for autocorrelation. In addition, a Hausman test is used to choose between random effect model and fixed effect model. Because the *p-value* from the BP test was near zero (<.0001), the null hypothesis of homoskedasticity is rejected with a 1% significance level. Therefore, this data qualified as heteroskedastic. The Durbin-Watson (DW) statistic, *d*, is quite low, 0.901. With four independent variables including an intercept term and 2000 observations, the 1% one-tailed critical values were d_L = 1.89405 and d_H = 1.89804. Because $d < d\ L$, our data likely exhibits autocorrelation. Because of the near zero *p-value (< .0001)* from the Hausman test, the null hypothesis is rejected. Therefore, the fixed effect model is more appropriate. Table 8 presents fixed effect regression results.

Table 8 **Result from Fixed Effect Model**			
	Coefficient	T-Value	p-Value
Intercept	-2.67865	-5.59	< .0001
LN(Assets)	0.139846	6.72	< .0001
ISR	-4.76086	-111/05	< .0001

The result of analysis II shows that a significantly negative relation exists between a firm's ISR and the firm's PM. A smaller value for the ISR ratio indicates the firm is more efficient at managing inventory. Therefore, the negative relation between firm PM and ISR supports the *Hypothesis* as we find that firms with better inventory management efficiency show higher profitability. The R^2 from our regression estimation is 0.7495, indicating that our model has a strong fit. The F-statistic of 7.99 for our model is significant at the 0.01% level. The result from the analysis II validates the result from analysis I, i.e., there is a negative relationship between ISR and PM. Therefore, our results indicate that efficient inventory management practices have a positive effect on firm's profitability.

CONCLUSION

While inventory management has been common practice in business for many years, there has been an evolution for inventory management from JIT to lean inventory systems to supply chain management. However, the supposition about the cost/benefits of the implementation of inventory management is both conflicting and dated. The purpose of this study is to determine if a relationship exists between inventory management efficiency and firm profitability. First, to be more precise, the logical analysis is that the management of the appropriate inventory levels would result in an inverse relationship between the optimized inventory levels and firm profitability. Second, we attempt to expand the investigation to determine the impact of inventory efficiency by firm size and, finally, offer corroborative evidence by using more recent data. Our results show a positive relation between profitability and inventory management efficiency. In addition, the impact of that inventory efficiency on profitability based on firm size was noticeably significant.

In the first model, we control for firms size with binary dummy variables concerning revenue. In the second model, we control for firm size with a continuous variable measuring asset size. Both models show same result for the relation between ISR and profitability. While both models significantly support the inverse relationship between lower inventory levels and increase in profitability, the results for the firm size are significantly noticeable. In the first model, the result shows that the smaller category of firm size has a stronger negative effect on its profitability. However, in the second model (based on asset size) and overall general comparison of manufacturing firms, there is a positive effect of firm size on profitability. This adds corroborating evidence to the overall analysis and supportive evidence to the inventory level/profitability relationship. From our results that are robust to time period and measurement variation, we conclude that more efficient inventory management practices result in higher firm profitability.

Finally, it is important to include further analysis concerning the impact of inventory efficiency and firm size. As seen in Table 2, the impact of inventory efficiency is potential greater in small size firms as opposed to medium and large size firms. In other words, it is possible to conclude that small size firms can receive a larger benefit (as measured by profitability) from increased inventory efficiency when compared to medium and large size firms. It could be concluded that the potential for improvement is greater in the smaller firms. One possible explanation for this is that the medium and larger manufacturing firms have already implemented fully technological advanced inventory management systems and have already maximized its potential effect of inventory efficiency. The smaller firms could have greater room for improvement by increasing inventory efficiency.

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