Atlantic Marketing Journal

Volume 7 | Number 2 Article 1

2018

Trends in Manufacturing Inventory Efficiency: 1980-2013

Ahren Johnston
North Carolina A & T State University, ajohnston@ncat.edu

Trends in Manufacturing Inventory Efficiency: 1980-2013

Ahren Johnston, North Carolina A & T State University

ajohnston@ncat.edu*

Abstract — This study was motivated by Cooke's 2013 article questioning the inclusion on inventory carrying costs in CSCMP's Annual State of Logistics Report since it is based on interest rates. This paper explores that question more fully and goes on to look at trends in inventory efficiency based on inventory turnover for U.S. manufacturing firms. Results of the study reveal that there has been a level trend between 1980 and 2013 after firm size is controlled for. Since these results are contradictory to those obtained by looking at inventory carrying costs as a percent of GDP, they suggest the need for a measure which controls for interest rate to be included in the State of Logistics Report.

Keywords — Inventory, Logistics, Trends, Efficiency

Relevance — This paper is relevant to anyone who is involved in inventory management whether through marketing, logistics, operations management, or supply chain management.

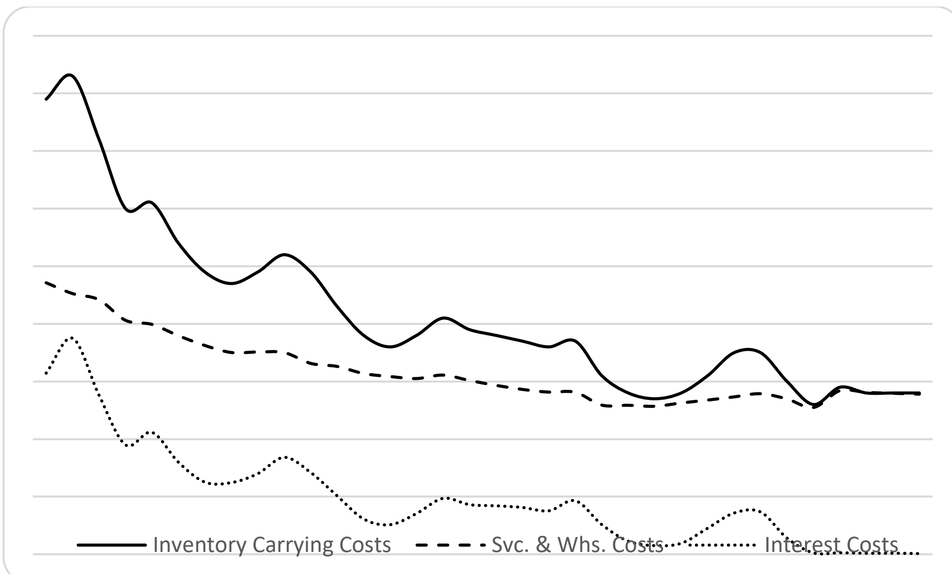
Introduction

In the October 2013 issue of the Council of Supply Chain Management Professionals' (CSCMP) Supply Chain Quarterly, an editorial was printed questioning the inclusion of inventory carrying costs (ICC) in CSCMP's annual "State of Logistics Report" (Cooke, 2013). The basis of Cooke's argument was that U.S. logistics costs as a percent of GDP is used to highlight efficiencies in logistics management, yet logisticians have no influence over one of the

ISSN: 2165-3879 (print), 2165-3887electronic)

key factors used to estimate carrying costs, the commercial paper rate. If this leads to an inaccurate measure of inventory efficiency, it is important to explore other measures to see if the accepted patterns remain. This study will first add some data analysis to Cooke's argument that ICC as a percent of GDP does not show efficiencies then examine a different measure of inventory efficiency, inventory turnover (IT), in order to highlight any temporal trends since 1980. To bolster Cooke's argument, Figure 1 shows that a key factor in the reduction of ICC as a percent of GDP since 1980 has been the decrease in interest costs as a percent of GDP[1], and Figure 2 illustrates that a key factor in the reduction of total logistics costs as a percent of GDP has been the decrease in ICC as a percent of GDP.

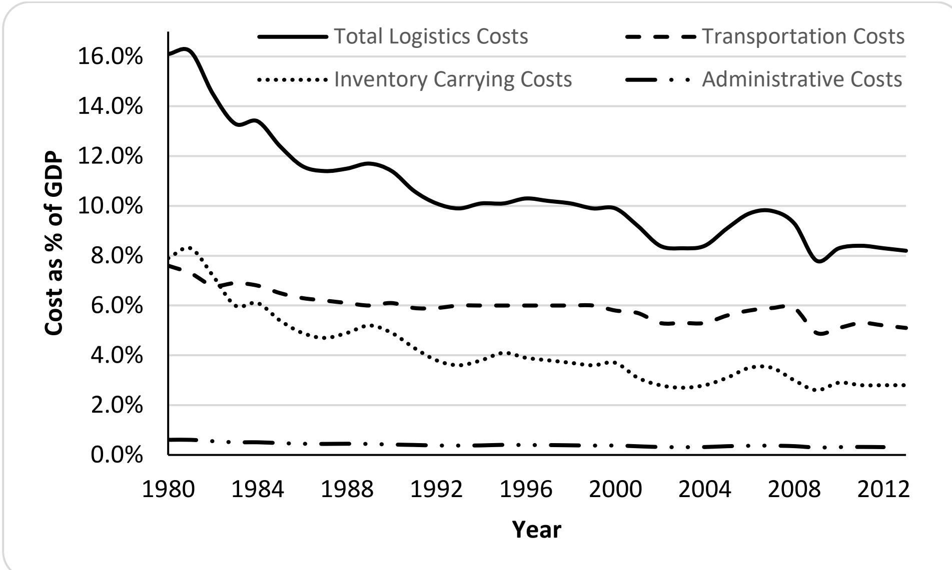
Figure 1
Inventory Carrying Cost and Components as a Percent of GDP*



*Source: Board of Governors of the Federal Reserve System (2014a: 2014b); Wilson and Delaney (2001); Wilson (2014)

[1] Interest cost as a percent of GDP is calculated as the annualized commercial paper rate multiplied by total business inventories and divided by US GDP.

Figure 2
Total Logistics Cost and Components as a Percent of GDP*



*Source: Wilson and Delaney (2001); Wilson (2014)

As evidenced by the virtually identically sloped lines in Figures 1-2, interest costs are driving ICC, which are driving total logistics costs. Regression analyses which correct for first order auto-correlation reveal that 99% of the variation in ICC can be explained by interest costs, 99% of the variation in logistics costs can be explained by ICC, and finally, more than 96% of the variation in US logistics costs as a percent of GDP can be explained by the commercial paper rate. Table 1 shows a summary of these macro level equations and estimated coefficients. These estimates suggest that total logistics costs as a percent of GDP may be no better at showing logistics efficiency than interest rates, and the widely touted "increased efficiency" in US logistics costs since 1980 appears to be the result of reduced interest rates. However, the strong correlation between interest rates and ICC seems to be masking the increased efficiencies in transportation and administrative costs. Additionally, individual companies, and even industries, likely have seen increased efficiencies through better sourcing decisions, inventory management and/or transportation management.

Although ICC as a percent of GDP as calculated and reported in CSCMP's annual "State of Logistics" reports seems to have limited usefulness in identifying increases in inventory efficiency, it is important to know whether there have been increases in inventory efficiency for US firms. While there is likely a way to adjust ICC to account for interest rates, it is also possible to look at other measures of efficiency, and inventory turnover[2] (IT) is one such measure.

[2] IT is measured as COGS divided by Average Inventory Investment, so any increases in inventory turnover would indicate increased efficiency in inventory management.

Table 1
Preliminary Regression Analyses

Fitted Equation	Rho	R^2
$ICC = 0.03^* + 1.27^*(Interest\ Costs)$	0.9092	0.9933
$Total\ Logistics\ Costs = 0.05^* + 1.44^*(ICC)$	0.3020	0.9894
$Total\ Logistics\ Costs = 0.08^* + 0.42^*(Commercial\ Paper\ Rate)$	0.7441	0.9628
*Significant at the 0.001 level		

Therefore, the purpose of this study is to investigate the trend in IT of US manufacturing firms since 1980. Improved information technology, improved forecasting techniques, increased outsourcing, faster modes of transportation, increased product proliferation, lengthening supply lines, and improvements to customer service, have all likely contributed to inventory turnover. Previously published studies have shown that there appears to be a trend of increasing IT for US retailers and wholesalers, but after controlling for firm size, the trend in IT for retailers and wholesalers is level for the last 32 years ([name deleted to maintain the integrity of the review process], 2014a; 2014b).

Unlike previously published studies, this study will investigate the overall trend of manufacturers' IT and uses a very large, balanced set of panel data spanning a time period of 32 years. This balanced data set allows for greater flexibility in the choice of analytical techniques.

Literature Review

While not a major focus of empirical research, there is a modest body of literature related to inventory performance, even if not the primary focus. An overview of the existing research of relevance follows.

Gaur et al. (1999) wrote a working paper exploring retail performance in terms of long run stock return. Results of their analysis confirm an inverse logarithmic relationship between IT and gross margin and show that 64% of the variation in IT can be explained by gross margin. Based on this incidental result, Gaur et al. (2005) investigate the correlation between retailers' inventory turnover and gross margin, capital intensity, and sales surprise between 1985 and 2000. By using time specific dummy variables in the analysis, they find that inventory turnover appears to be decreasing over time. While their study focused on retailers, it seems likely that many of these relationships apply to manufacturers.

Rajagopalan and Malhotra (2001) researched whether inventories decreased between 1961 and 1994. Results of their analysis show that raw materials and work in process inventories decreased in most industry sectors, and finished goods inventory levels varied by industry sector.

Chen, Frank, & Wu (2005) performed an analysis of manufacturers' inventories between 1981 and 2000 and find that raw material and work in process inventories declined significantly and finished goods inventories remained steady. Chen, Frank, & Wu (2007) investigate inventory performance of retailers and wholesalers for a time period of 1981-2004 and find that manufactures and wholesalers have seen steady improvements in inventory performance.

Rumyantsev and Netessine (2007) examined inventory levels for a variety of manufacturers, wholesalers, and retailers between 1992 and 2002. They found evidence for economies of scale in that larger firms have relatively less inventory than smaller firms. These results motivated Gaur and Kesavan (2009) to include firm size, measured as annual sales, as an explanatory variable in their model investigating inventory turnover. Using retailer data from 1985-2003, Gaur and Kesavan (2009) find evidence for diminishing returns to scale but do not report on temporal trends.

Finally [authors' name(s) withheld to preserve integrity of review process] (2014a; 2014b) examined trends in inventory performance of both retailers and wholesalers and found that after controlling for firm size, the apparent increasing trend in inventory turnover virtually disappeared. This study extends this work to ascertain whether the same holds true for manufacturers. Furthermore, the use of a set of balanced panel data allows for more robust results.

Data

The data used in this study was obtained from Standard and Poor's Compustat North America (2013) with the exception of the Implicit Price Deflator obtained from the BEA (2013). Data from annual income statements and balance sheets for publicly traded US manufacturing firms was obtained over a time period from 1979 through 2012. Specific data included total revenue, gross income, net income, net fixed assets, inventory and total assets.

Firms were selected from the manufacturing establishment SIC codes, 2000 – 3990. This resulted in a total of 434 firms. In order to obtain a balanced panel, the sample was reduced to those 340 firms with complete data available.

The dependent variable used was IT. This is a commonly used measure of inventory efficiency and indicates a firm's cost of goods sold relative to average inventory investment, so larger values indicate greater efficiency. Because the natural logarithm of IT (a transformation employed) is highly correlated with the natural logarithm of other measures of inventory efficiency such as days of inventory and inventory to sales ratio all of these measures would result in similar results.

Independent variables selected based on the existing body of research include gross margin, capital intensity index (as defined by Stickney and McGee, 1983), growth index and firm size. Additionally, net margin was used as an independent variable because firms with high IT may have low gross margins but should be efficiently managing their total logistics costs to see improved profitability. Because net margin was negative for some observations, prohibiting the log transformation, unity less net margin was used as a proxy for net margin and denoted as expense ratio (ER).

The following details the calculation of the variables used in this study:[3]

Inventory Turnover: $IT = \frac{COGS}{(Inv_t + Inv_{t-1})/2}$

Adjusted Sales: $AS = \frac{S}{ipd/100}$

[3] Let COGS denote cost of goods sold, Inv denote inventory, S denote sales, GI denote gross income, ipd denote implicit price deflator, NI denote net income, NFA denote net fixed assets and TA denote total assets.

Gross Margin: $GM = \frac{GI}{S}$

Expense Ratio: $ER = 1 - \frac{NI}{S} = 1 - Net\ Margin$

Capital Intensity: $CI = \frac{NFA}{TA}$

Growth Index: $GI = \frac{S_t}{S_{t-1}}$

Table 2 lists the average value and standard deviation of each variable every five years and for the overall sample. As can be seen from the table there is significant variance of each variable for each year listed as well as for the entire sample. The final data set used for estimation consisted of 11,220 observations on 340 firms over 33 years.

Table 2
Mean (Std. Dev) of Variables

Year	Inventory Turnover	Adjusted Sales $MM	Gross Margin	Expense Ratio	Capital Intensity	Growth Index
1980	7.11 (23.83)	$4,356.26 (15,862.17)	0.32 (0.13)	0.94 (0.05)	0.32 (0.14)	1.04 (0.17)
1985	6.05 (8.39)	$3,999.21 (12,590.68)	0.34 (0.14)	0.96 (0.10)	0.33 (0.15)	1.07 (0.57)
1990	6.28 (12.88)	$5,293.70 (15,729.48)	0.34 (0.15)	0.95 (0.08)	0.32 (0.15)	1.04 (0.14)
1995	6.19 (5.13)	$5,971.79 (17,008.60)	0.35 (0.15)	0.94 (0.06)	0.31 (0.15)	1.11 (0.18)
2000	6.37 (6.68)	$7,540.08 (22,453.09)	0.36 (0.15)	0.96 (0.20)	0.29 (0.15)	1.08 (0.23)
2005	6.89 (6.15)	$9,449.34 (28,835.78)	0.35 (0.16)	0.94 (0.13)	0.24 (0.13)	1.06 (0.19)
2010	6.57 (5.94)	$9,385.66 (26,749.28)	0.36 (0.16)	0.94 (0.09)	0.23 (0.14)	1.11 (0.25)
Overall Mean	6.46 (11.02)	$6,614.58 (20,742.40)	0.35 (0.15)	0.95 (0.10)	0.29 (0.15)	1.05 (0.22)

Hypothesis Development

The following hypotheses were developed as related to trends in IT as well as the control variables.

H1: Inventory turnover is positively correlated with firm size as measured by adjusted sales.

Increases in firm size should lead to increases in both economies of scale and economies of scope, allowing for more efficient inventory management and increased IT

H2: Inventory turnover is negatively correlated with gross margin.

One strategy employed to reduce inventory levels is to use faster and more reliable forms of transportation such as motor carrier rather than rail. This allows a company to order in smaller quantities and reduce safety stock by reducing length and variation of the order cycle. Because inventory and the cost of goods sold are commonly recorded at a landed cost, this change in transportation strategy should be associated with a higher IT and a lower GM.

H3: Inventory turnover is negatively correlated with expense ratio (positively correlated with net margin.

A firm focusing on logistics or logistics management should be making tradeoff decisions that seek to minimize total costs. In many instances, these decisions result in decreased inventory carrying costs made possible by faster or more reliable transportation (at a premium price). This decision could lead to increased IT along with increases to net margin.

H4: Inventory turnover is negatively correlated with capital intensity.

A company that outsources some or all of its manufacturing would likely be able to replace capital intensive investments in manufacturing equipment with warehousing while at the same time reducing or eliminating work-in-process and raw materials inventory. The net effect would likely be reduced capital intensity and inventory levels (leading to increases to IT.

H5: Inventory turnover is positively correlated with growth index.

A company experiencing more rapid growth would likely under-forecast if using the popular method of exponential smoothing. Conversely, a firm that under-forecasts would likely have lower inventory levels and higher inventory turnover.

H6: Inventory turnover has been increasing over time.

Although the introduction discussed how the apparent increased inventory efficiency seen in the "State of Logistics Reports" is primarily the result of a decrease in interest rates, it is also likely that an increased focus on logistics has led to increased inventory efficiency.

Statistical Model

The general model tested is that IT can be predicted using a function of the form:

$IT = f(AS, GM, ER, CI, GI, f, t)$. Where: $f =$ firm effects, $t =$ time effects, and the other variables are as previously defined. Because differences between firms were not the focus of this study and to allow for more efficient estimation, for each firm, the mean value of each variable was subtracted from each observation of that variable. This results in the removal of firm effects and differences resulting from accounting policies, management style, etc. A log-log model was employed, so that each estimated coefficient can be interpreted as the percent change in IT given a one percent change in the independent variable. This allows for a straightforward interpretation of the results especially as related to ratios[4].

[4] For improved clarity, an example of the transformation of IT follows: $\ddot{IT}_{ft} = \ln(IT_{ft}) - \frac{\sum_t \ln(IT_{ft})}{33}$

To look at differences from the control year (1980), dummy variables are used for each year, following a calculation described by Kennedy (1981), the coefficient associated with each year's dummy variable will signify the percentage difference in IT between the subject year and 1980 (the control year)5. To look for an overall temporal trend, a secondary model was developed, which substituted the year specific dummy variables with an interval variable for year. Additionally, models with tested that included size, as measured by adjusted sales, and that restricted the size coefficient to zero in order to test whether controlling for size had any impact on the temporal trend. This leads to the following specific models.

Model 1a:

$$\ddot{IT} = \beta_1\ddot{GM} + \beta_2\ddot{EP} + \beta_3\ddot{CI} + \beta_4\ddot{GI} + \sum \delta_t\ddot{Y}_t \quad (1)$$

Model 1b:

$$\ddot{IT} = \beta_1\ddot{GM} + \beta_2\ddot{EP} + \beta_3\ddot{CI} + \beta_4\ddot{GI} + \beta_5\ddot{T} \quad (2)$$

Model 2a:

$$\ddot{IT} = \beta_1\ddot{AS} + \beta_2\ddot{GM} + \beta_3\ddot{EP} + \beta_4\ddot{CI} + \beta_5\ddot{GI} + \sum \delta_t\ddot{Y}_t \quad (3)$$

Model 2b:

$$\ddot{IT} = \beta_1\ddot{AS} + \beta_2\ddot{GM} + \beta_3\ddot{EP} + \beta_4\ddot{CI} + \beta_5\ddot{GI} + \beta_6\ddot{T} \quad (4)$$

Where:

$\ddot{IT} = Inventory\ Turnover$

$\ddot{AS} = Adjusted\ Sales$

$\ddot{GM} = Gross\ Margin$

$\ddot{EP} = Expense\ Percentage$

$\ddot{CI} = Capital\ Intensity$

$\ddot{GI} = Growth\ Index$

$\ddot{Y}_t = Year\ Specific\ Dummy\ Variable$

$\ddot{T} = Year\ Interval\ Variable$

Estimation and Results

Equations 1 through 4 were estimated with the Pool command in Shazam Econometrics Software. Pooled OLS was applied to data transformed to correct for serial correlation with a different autocorrelation coefficient for each firm and panel corrected standard errors (adjusted for cross-section heteroskedasticity and cross-section correlation) were reported. For additional details on the estimation technique, see Whistler et al. (2011).

[5] This adjustment has minimal impact on coefficients of low magnitude (as seen in the estimation), so only the coefficients are indicated on Table 3, but both the estimated coefficients and transformed coefficients will be shown on Figures 3-4.

Table 3 details the results of the analyses and will be employed to test Hypotheses 1-6. As indicated by the asterisks to the right of the estimated coefficients, most of the variables are highly significant and similar across all models; however, there are some notable differences in both the year specific variables of Models 1a and 2a and the year interval variable of Models 1b and 2b when firm size, as measured by adjusted sales, is controlled for. As can be seen from the R2 values, Log of the Likelihood Function (LLF), and Sum of Squared Errors (SSE), Models 2a and 2b provide the best fit to the data and indicate that it is appropriate to control for firm size.

Although there are some minor differences in magnitude, the estimated coefficients for all control variables were of the same direction and significance across all four models. For that reason, Model 2a, which provided the best fit to the data, will be used for testing Hypotheses 1-5.

Hypothesis 1 is supported, and a 1% increase in firm size is associated with a 0.19% increase in IT. As expected, firms with a larger scale and/or scope are better able to manage their inventory. Much of these scale and/or scope economies are likely related to the concept of risk pooling, which implies that more aggregate forecast should be better.

Hypothesis 2 is supported, and a 1% increase in Gross Margin is associated with a 0.24% decrease in IT. This is consistent with previous research (see for example: Gaur et al., 2005). This is likely the result of firms optimizing their total logistics costs by spending slightly more on inventory (at landed cost) in order to reduce their average inventory level and inventory carrying costs.

Hypothesis 3 is supported and a 1% increase in Expense Ratio is associated with a 0.06% decrease in IT. Conversely, an increase in Net Margin would be associated with an increase in IT. Similar to the reason higher IT is associated with lower gross margin, it is also associated with a higher net margin. This further supports the core logistics and supply chain management concept of minimizing total cost rather than just one aspect such as efficient inventory management.

Hypothesis 4 is supported, and a 1% increase in Capital Intensity is associated with a 0.04% decrease in IT. While this is contrary to the results of Gaur et al. (2005) in the retail industry, it is likely due to an increase in outsourcing since 1980 which would cause a decrease in capital intensive manufacturing equipment and an increase in less capital intensive warehousing to store outsourced products in anticipation of customers' orders.

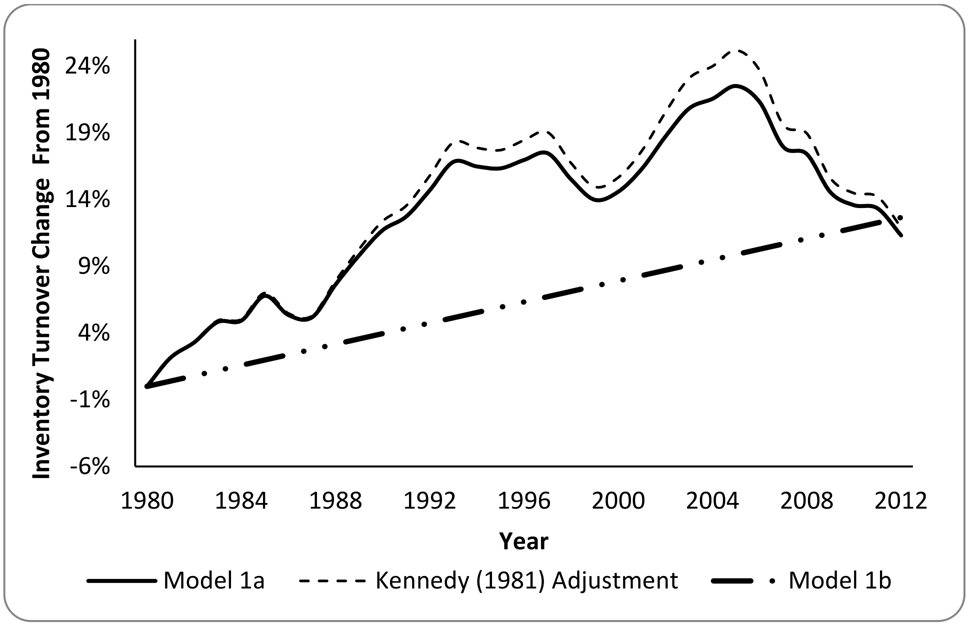
Finally, Hypothesis 5 is supported, and a 1% increase in Growth Index is associated with a 0.37% increase in IT. This result is, again, as expected because firms experiencing rapid growth and using an exponential smoothing forecasting technique would likely consistently under forecast demand and have less excess inventory.

Table 3:
Results of Estimation

Variable	Estimated Coefficient			
	Model 1a	Model 1b	Model 2a	Model 2b
Adjusted Sales	-	-	0.1861***	0.176***
Gross Margin	-0.252***	-0.253***	-0.2445***	-0.245***
Expense Percentage	-0.071***	-0.070***	-0.0624***	-0.061***
Capital Intensity	-0.033***	-0.029**	-0.0354***	-0.029**
Growth Index	0.461***	0.463***	0.3679***	0.375***
Year	-	0.004**	-	-0.001
1981	0.021**	-	0.0189**	-
1982	0.033***	-	0.0369***	-
1983	0.048***	-	0.0582***	-
1984	0.049***	-	0.0505***	-
1985	0.068***	-	0.0588***	-
1986	0.053***	-	0.0396*	-
1987	0.052**	-	0.0272	-
1988	0.076***	-	0.0357	-
1989	0.098***	-	0.0457*	-
1990	0.117***	-	0.0588**	-
1991	0.127***	-	0.0692***	-
1992	0.147***	-	0.0878***	-
1993	0.168***	-	0.1039***	-
1994	0.165***	-	0.0925***	-
1995	0.163***	-	0.0764***	-
1996	0.170***	-	0.0701**	-
1997	0.175***	-	0.0663**	-
1998	0.155***	-	0.0392	-
1999	0.140***	-	0.0193	-
2000	0.146***	-	0.0182	-
2001	0.163***	-	0.0356	-
2002	0.187***	-	0.0670**	-
2003	0.208***	-	0.0875***	-
2004	0.215***	-	0.0825**	-
2005	0.225***	-	0.0786**	-
2006	0.213***	-	0.0572	-
2007	0.179***	-	0.0152	-
2008	0.174***	-	0.0060	-
2009	0.145***	-	-0.0081	-
2010	0.136***	-	-0.0104	-
2011	0.133***	-	-0.0266	-
2012	0.113***	-	-0.0525	-
Buse (1973) R^2	0.4141	0.4065	0.4370	0.4284
LLF	5728.1	5656.8	5945.5	5862.9
SSE	216.74	219.55	208.34	211.49

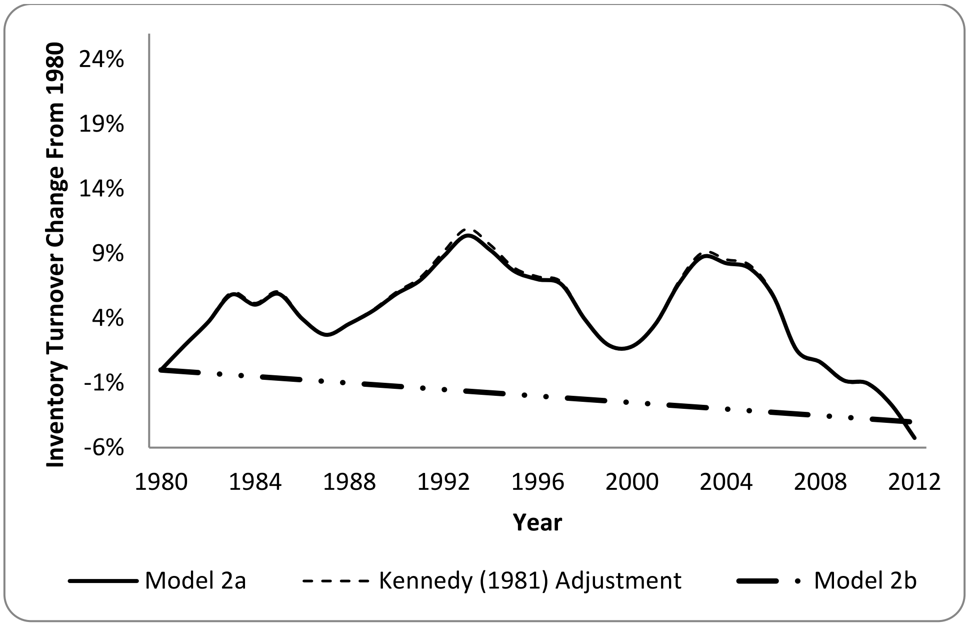
Models 1b and 2b are used to test Hypothesis 6 and illustrated in Figures 3-4, while Models 1a and 2a, along with the adjustments described by Kennedy (1981), are also shown in these figures to show the annual differences in IT. As can be seen in Figure 3, when firm size is not controlled for, there is a fairly strong increasing trend in the IT of manufacturing firms. With an average of a 0.4% increase in IT every year, the IT in 2012 is approximately 12% higher than it was in 1980.

Figure 3
Models 1a and 1b Trend w/o Controlling for Size



While this seems to indicate an increase in the efficiency of inventory management, Figure 4 illustrates that after controlling for firm size, the increasing trend in IT disappears. In fact it is replaced with a negative, though non-significant, decrease in IT of approximately 0.1% per year. These results show that much of the apparent increase in inventory efficiency is the result of economies of scope and/or scale associated with firm growth. These results are consistent with those of [authors' name(s) withheld to preserve integrity of review process] as related to publicly traded retailers and wholesalers (2014a; 2014b).

Figure 4
Models 2a and 2b Trend after Controlling for Size



Conclusion

This study was motivated by Cooke's 2013 editorial in CSCMP's Supply Chain quarterly questioning the inclusion of inventory carrying costs in the annual State of Logistics Report and began with a quick analysis of logistics costs as a percent of GDP since 1980 (near the time logistics became a focus of firms). The analysis showed that, at the aggregate level, 99% of the variation in total logistics costs as a percent of GDP could be largely explained by interest rates. The study then investigated temporal trends in retail efficiency as measured by inventory turnover. The results of the analysis revealed that, after controlling for firm size, there was no significant trend in the inventory efficiency of US manufacturers, thus revealing that the net impact of all the various factors impacting inventory has been no change. While there may not have been a significant increase in inventory efficiency, there have likely been increases in the efficiency of transportation and management. Transportation costs went from 7.6% to 5.1% of GDP, and administrative costs went from 0.6% to 0.3% of GDP (Wilson and Delaney, 2001; Wilson, 2014).

The results of this study, suggest that, Cooke was not wrong in suggesting that the inclusion of ICC, as currently calculated in the State of Logistics report, lends little insight into the efficiency of logistics management in the US. Just as the reported logistics costs as a percent of GDP control for inflation, it would be desirable to control for interest rates in the calculation of ICC. Such a calculation would likely show, as this study did, that there has been no real improvement in efficiency of inventory management at the macro level despite the fact that some firms have clearly improved their logistics management to reduce costs while improving customer service. Therefore, there is a need for an adjustment to the ICC used in the State of Logistics Report in order to more accurately show any changes to efficiency of inventory management among US firms.

References

(BEA) U.S. Department of Commerce: Bureau of Economic Analysis. (2013) *Gross Domestic Product: Implicit Price Deflator*. [online] Available from: http://www.bea.gov [accessed 07 November 2013]

Board of Governors of the Federal Reserve System. (2014a) *1-Month Prime Commercial Paper - Average Dealer Offering Rate.* [online] Available from: http://www.federalreserve.gov/releases/h15/data.htm [accessed 20 June 2014]

Board of Governors of the Federal Reserve System. (2014b). *30-Day AA Nonfinancial Commercial Paper Interest Rate*. [online] Available from: http://www.federalreserve.gov/releases/h15/data.htm [accessed 20 June 2014]

Buse, A. (1973) Goodness of fit in generalized least squares estimation. *The American Statistician*, 27 (3), 106-108.

Chen, H., Frank, M. Z., and Wu, O. Q. (2005) What actually happened to the inventories of American companies between 1981 and 2000? *Management Science*, 51 (7), 1015-1031.

Chen, H., Frank, M. Z., and Wu, O. Q. (2007) US retail and wholesale inventory performance from 1981 to 2004. *Manufacturing & Service Operations Management*, 9 (4), 430-456.

Cooke, J. A. (2013) U.S. logistics costs: are we measuring the right things? *Supply Chain Quarterly*, 2013 (Special).

Gaur, V., Fisher, M., and Raman, A. (1999) What explains superior retail performance? NYU Working Paper No. OM-2005-03.

Gaur, V., Fisher, M., and Raman, A. (2005) An econometric analysis of inventory turnover performance in retail sales. *Management Science*, 51 (2), 181-194.

Gaur, V. and Kesavan, S. (2009) The effects of firm size and sales growth rate on inventory turnover performance in the U. S. retail sector. In *Retail Supply Chain Management*. edited by N. Agrawal and S. A. Smith, 25-52. New York, Springer.

Kennedy, P. E. (1981) Estimation with correctly interpreted dummy variables in semilogarithmic equations. *American Economic Review*, 71 (4), 801.

Rajagopalan, S. and Malhotra, A. (2001) Have US manufacturing inventories really decreased? an empirical study. *Manufacturing & Service Operations Management*, 3 (1), 14-24.

Rumyantsev, S. and Netessine, S. (2007) What can be learned from classical inventory models? a cross-industry exploratory investigation. *Manufacturing & Service Operations Management*, 9 (4), 409-429.

Standard and Poor's Compustat North America. accessed 06 November 2013.

Stickney, C. P. and McGee, V.E. (1983) Effective corporate tax rates the effect of size, capital intensity, leverage, and other factors. *Journal of Accounting and Public Policy* 1 (2), 125-152.

Whistler, D., White, K. J., Bates, D., and Golding, M. (2011) *Shazam Reference Manual Version 1.1.* Cambridge, England: Shazam Analytics, LTD.

Wilson, R. and Delaney, R. V. (2001) *12th Annual State of Logistics Report*. Chicago, IL: The Council of Supply Chain Management Professionals.

Wilson, R. (2014) *25th Annual State of Logistics Report*. Chicago, IL: The Council of Supply Chain Management Professionals.

Author Information

Ahren Johnston

Dr. Ahren Johnston is an Associate Professor of Supply Chain Management at North Carolina Agricultural and Technical State University. Dr. Johnston's research interests include transportation economics, inventory policy, and pedagogy. He has published in journals such as Transportation Research Part E, Transportation Journal, Journal of Operations Management, Journal of Transportation Management and the Atlantic Marketing Journal.