Just-In-Time Production Systems: Financial Results of Adopting Firms

By
Kanalis Ockree*

WASHBURN UNIVERSITY
SCHOOL OF BUSINESS
WORKING PAPER SERIES
Number 29

August 2004

Washburn University
School of Business
1700 SW College Ave.
Topeka, KS 66621
785-231-1010, extension 1308
www.washburn.edu/sobu

* Kanalis Ockree is associate professor of accounting at the School of Business at Washburn University, Topeka, Kansas. Comments should be directed to Kanalis Ockree, School of Business, Washburn University, 1700 SW College Ave., Topeka, Kansas 66621, 785-231-1010, extension 1589, kanalis.ockree@washburn.edu.

JUST-IN-TIME PRODUCTION SYSTEMS: FINANCIAL RESULTS OF ADOPTING FIRMS

Kanalis Ockree
Washburn University
School of Business
1700 College Avenue
Topeka, KS 66621
(785)231-1010, Extension 1589

ABSTRACT

Despite the popular and business press coverage given JIT, only minimal empirical evidence is available that provides support for the existence of the financial benefits attributed to a JIT production system. This paper develops empirical and theoretical linkages between JIT and financial reporting systems, analyzes financial reports of 31 companies identified as successful JIT adopters (experimental firms), and compares these firms systematically on common variables with a matched set of 31 non-JIT companies (control firms).

INTRODUCTION

Theoretical and empirical linkages between Just-in-Time [JIT] adoption and firm performance are examined in this study. Comparative analysis of 31 matched pairs of manufacturing firms shows that return on sales is higher for JIT firms. In addition logit model analysis identifies JIT firms as significantly different from their matching firms using return on sales, cost ratio, inventory turnover and inventory as a percent of sales as the model variables.

Following this section, in order, come hypothesis development, a description of the methodology and sample selection, and the analysis of results of the study. Thereafter, a summary of the paper as a whole and the contributions and limitations of the study are given, followed by the conclusion. The conclusion also provides possible avenues for further research in this area.

BACKGROUND

There is currently little systematic empirical research addressing the issue of the measurable financial effects of JIT implementation. If a firm is outperforming competitors due to JIT, that information should be captured in the financial reports. This of course implies appropriate implementation of JIT and adaptation of business systems to the JIT model [Chikkara and Weiss, 1995].

JIT as defined early on by Schonberger [1986] consisted of a synchronized parts delivery system focused on minimizing inventory for the purchasing firm. A broader concept of JIT expands the scope of JIT far beyond the concept of inventory control. "[JIT] is a system of production control that seeks to minimize raw material and work-in-process inventories; control (eliminate) defects; stabilize production; continuously simplify the production process; and create a flexible, multi-skilled work force." [Calvasina, et al 1989]. This philosophy requires changes in strategy and philosophy related to production across the board, so that minimum inventory operations facilitate the minimum cost operation of an entire production and distribution system. For the research undertaken here JIT implementation is defined as a pervasive operating philosophy of continuous improvement related to production operations and delivery systems, the latter definition.

A well planned system of JIT provides for much clearer traceability of cost to products. When a firm has adopted JIT, cost savings and competitive improvements should ultimately become evident in reported financial results in the form of increased sales, relative cost savings and therefore increased reported earnings.

JIT information, as with most internal accounting and production matters, is considered proprietary by most firms and therefore adopters provide little publicly available direct information on the outcomes and effects of JIT. There is public information in the form of case studies for particular firms with descriptive data of the JIT process and how JIT affects specific

operations. Some firms announce in annual reports expected implementation of a JIT system. But, the majority are largely silent on the topic until top management consents to a case study to report the "phenomenal success" of their JIT operation.

Financial statement benefits of adoption of JIT should include, at a minimum, effects on the variables indicated below. A noticeable reduction in both work in process, and raw materials inventories should be the first outcome for most adopters. If expected efficiencies are realized there should also be a reduction in cost of goods sold as a proportion of sales [CR], assuming prices are not adjusted downward when cost savings arise. Earnings before tax as a percentage of sales [ROS] should also increase as JIT becomes fully operational. The ROS increase is expected due to savings from reorganization and decentralization of service departments as well as the reduction of inventory holding costs including possible related short term interest payments. If inventories are reduced and sales levels maintained or increased there should also be an evident increase in the inventory turnover ratio [INVTO] and a reduction in inventory holdings in proportion to sales levels [INVR].

These outcomes are not expected to be immediately reflected in financial reports. Adoption of any major change takes time to implement. This is true of JIT in both a physical and a managerial sense. Major adjustments in the way production managers and workers alike view themselves and their jobs and the methods of operating together are absolutely essential for JIT to be successful. According to Patell [1987] JIT adoption is an evolutionary rather than a revolutionary process. Additionally, adoption usually begins within a division or department and spreads incremental through the organization [McLachlin and Piper, 1990]. Therefore, while statistical tests will be applied to the first year following adoption, the major impact of JIT is expected to be found in the second and later years. The analysis performed here is viewed as a necessary first step in an effort to determine if firm-wide economic effects of JIT are detectable from reported annual financial data.

HYPOTHESIS DEVELOPMENT

Quality and design improvements that go hand-in-hand with JIT adoption should improve customer relations and product reputation. Delivery improvements should also impact these areas. Cost savings should be reflected in a more competitive price for products. Therefore, JIT adoption should lead to increased sales and/or higher return on sales. Return on sales is measured as reported earnings before tax as a percentage of net sales revenue.

H1: JIT firms will experience greater return on sales than non-JIT firms in the same industry due to cost savings and competitive advantage.

More efficient operation in production processes, cellular design, multi-machine manning, and cross training of production workers should produce large savings in product cost. From these economies product cost should decrease.

H2: JIT firms will have lower cost of goods sold as a % of sales than non-JIT firms.

The inventory reduction focus of JIT systems should lead to lower raw materials (RM) and work in process (WIP) inventories than previously held by adopting firms. In addition, demand pull production planning should reduce finished goods inventory. Few firms report these inventories as separate items. Therefore, a comparative reduction in total inventory between experimental and control firms should be expected. It is possible, however, that RM and WIP inventory reduction may not be captured in total inventory due to the level production characteristics of JIT and commitments to maintain work force levels. In addition, improved supplier relations and accelerated supplier deliveries should increase inventory turnover.

H3: JIT firms will experience a higher inventory turnover than non-JIT firms, other things being equal.

H4: JIT firms will have lower reported total inventory as a percent of sales than non-JIT firms.

If supported, these hypotheses indicate that JIT accomplishes what is intended, that is, a competitive advantage for adopting firms, at least in the near-term. And, from an accounting perspective, those differences are being captured in external financial reports. Significant results should also indicate the necessity for consideration of a JIT philosophy by any firm facing competitors that have adopted or are expected to adopt JIT. Table 1 summarizes these hypotheses.

Table 1
HYPOTHESES:

H_1: ROS
FOR JIT FIRMS > NON-JIT FIRMS

H_2: COGS/SALES
FOR JIT FIRMS <NON-JIT FIRMS

H_3: INVENTORY TURNOVER
FOR JIT FIRMS >NON-JIT FIRMS

H_4: INVENTORY/SALES
FOR JIT FIRMS <NON-JIT FIRMS

Methodology and Sample Selection

Identification of JIT firms for this study began with a search of the National Automated Accounting Research

System (NAARS). This search identified eleven usable adopting firms and their year of JIT adoption. Other firms were added as they were identified in articles or books concerning JIT adopters that included information identifying the initial adoption year, as follows: 8 firms from Schonberger [1986]; 3 from Schonberger [1987]; 1 firm from a Wall Street Journal article [O'Boyle, 1990]; and 7 from three different Industry Week articles in a series on quality manufacturing. Inclusion required that firms have financial data available on the Compustat tapes for one year prior to the adoption year and for at least two years thereafter.

Experimental firms matched control firms based on SIC code listed in Compustat for 1986 and on sales in the year prior to JIT adoption to accommodate a matched pairs design. Four digit SIC codes are used with one exception, where a three digit code was used in order to get a usable size match. The control firm in each pair represents the firm closest in sales volume to the experimental firm within the same 1986 SIC code classification. Economic constraints were believed to be different for firms with a very large size difference as measured by the sales variable.

After identifying matching firms following the above procedure, a search was made of references in the Business Periodicals Index, the production engineering literature, case studies, and various other sources for reference to these firms as adopters or users of JIT. A NAARS search on the JIT key word and variations was also used to determine if these firms referred to the use of JIT in their financial reports during the study period. No control group firms were eliminated by this process.

The financial variables sales, cost of goods sold, inventory, and earnings before tax, for the first year prior to adoption and for the first, second and third year following adoption were extracted from the Compustat tapes. In addition, information related to disposals and acquisitions by firms during the test periods was taken from the tapes. Adoption years ranged from 1980 to 1987. It was necessary to limit the future period to three years following adoption for two reasons: 1) so that information for the post period would be available within the necessary time frame for all firms on the Compustat tapes currently available at the University of Kansas; and 2) it is believed that beyond this time frame the association between JIT and the variables, if found, is likely to be confounded by other events.

The process of matching pairs of firms controls for size and industry differences in the sense that economic events may generally affect firms of the same size in the same industry in the same way. To rule out possible endogenous relationships between JIT adoption and economic factors, initial statistical analysis of paired sample firms was performed to provide a profile comparing selected variables for the pairs in the first year prior to JIT adoption [Foster, 1980]. The selected variables were sales, cost of goods sold, and finished goods inventory [inventory]. Results of this analysis show these variables were not significantly different between control and experimental firms in the pre-test period, the year just prior to JIT adoption as well as for the two preceding years.

Mean difference paired t-tests and Wilcoxon signed ranks matched pairs test were used to analyze variable relationships for the sample pairs. The Wilcoxon test is a non-parametric statistical measure and represents a more appropriate technique for 1) small sample comparisons, and 2) when underlying normality is not assumed and when testing involves the comparisons of paired data.

These statistical tests were used to analyze differences between experimental and control group variables in the year one period prior to the adoption year and the periods one, two and three years following the adoption year.

If independent variables are correlated it is possible some of the results reported for the preceding tests may be misleading. That is, an unimportant variable in the univariate models may be a surrogate for some other variables and therefore generate a "false positive" result [Bowen, et al; 1981]. In order to improve the power of the test over the univariate and nonparametric statistical methods and to address issues of covariance, multi variate analyses were carried out using logistic regression models.

Logistic analysis applies when the dependent response function in a regression model is binary. Logit and probit analysis were first introduced as an appropriate method for differentiating accounting choice by Hagerman and Zmijewski [1979, pp.150-151]. Logit regression is used in this study because the small sample size may lead to the violation of the probit model assumptions of constant and normally distributed error variance [Neter, et al; 1989]. Adopting the method used by Bowen, et al [1981] as adapted by Ayres [1986] the test variables are the differences between the matched pairs on each variable for the same periods indicated in the univariate tests. The paired firms were randomly assigned to two groups. In the first group, on each independent variable, the value for the control firm was subtracted from the value for experimental firm, $(X_f - X_p)$. In the second group, the values for the experimental group were subtracted from the values for the control group, $(X_p - X_f)$. The response variable was assigned a value of 1 for the pairs in the first group and 0 for pairs in the second group. Although small sample size limits the generalizability of the results, this second set of tests may provide support for the original test results, as well as, aid in determining the effects of correlation among the variables in the model. This method also allows for a broad test

of difference between the two groups that is not possible with nonparametric tests.

IV. Results of the Study

Univariate tests : Tests of profile variables indicate that the two groups differed insignificantly in the three year period prior to JIT adoption by the experimental firm. This result, not provided here, indicates the firms are appropriately matched for the comparison study. Table 2 provides the results of the Wilcoxon signed ranks matched pairs tests.
T statistics tests, also performed, indicate that the assumption of an underlying lack of normality is appropriate. Therefore, the Wilcoxon results appear to be most reliable for this analysis and are reported here.

Statistical results support hypothesis three, the proposition that JIT firms turnover inventory more often than non-JIT firms. The difference in the change of inventory turnover [INVTO] rates for the two groups is highly significant in all three periods. Results also support H4,, the change in inventory as a percentage of sales [INVR] differs significantly between the two groups for all three periods. The three period difference in the rate of change in return on sales [ROS] is also highly significant in teh first two post adoption periods, providing support in both magnitude and direction for hypotheses one. The change in cost ratio is not significantly different between the pairs, therefore, support is not given to H3.

The non-significant test results on CR may be explained by a concomitant reduction in sales price by the firm. Other cost savings that occur "below" the gross margin on the income statement such as interest costs and warehousing costs may be reflected in the final financial results. Inventory reductions and cost savings can be managed internally to the firm while changes in sales are more of an external measure. In addition, a significant portion of JIT savings comes through reduction of non-product cost such as interest and storage costs. These savings should impact return on sales rather than the cost ratio.

In a study of this nature, the comparison of the relative value of single variables can be problematic. Differencing and using relative measures (ratios) aids comparison and also helps remove some of the correlation problems inherent in all analyses using economic data [Christie, 1987].

Multivariate tests: The logistic model measures the probability that an observation belongs in one of two groups. In order to maintain the control provided by the matched pair relationships and to perform the multivariate analysis in a format as close as possible to the univariate tests the variables in the logistic analysis are tested as differences between the pairs, as described below, and again as changes in those differences across years. To accomplish this, the method first used by Bowen, et al [1981] as extended by Ayres [1986] is adapted for

TABLE 2 - RESULTS
WILCOXON TESTS:
H_1: ROS FOR JIT FIRMS > NON-JIT FIRMS
YEAR 1 SIGNIFICANT $\alpha \leq .05$
YEAR 2 SIGNIFICANT $\alpha \leq .05$
YEAR 3 NOT SIGNIFICANT

H_2: COGS/SALES FOR JIT FIRMS >NON-JIT FIRMS
YEAR 1 NOT SIGNIFICANT
YEAR 2 SIGNIFICANT $\alpha \leq .10$
YEAR 3 NOT SIGNIFICANT

H_3: INV TO FOR JIT FIRMS >NON-JIT FIRMS
YEAR 1 SIGNIFICANT $\alpha \leq .01$
YEAR 2 SIGNIFICANT $\alpha \leq .025$
YEAR 3 SIGNIFICANT $\alpha \leq .01$

H_4: INV/SALES FOR JIT FIRMS <NON-JIT FIRMS
YEAR 1 SIGNIFICANT $\alpha \leq .01$
YEAR 2 SIGNIFICANT $\alpha \leq .01$
YEAR 3 SIGNIFICANT $\alpha \leq .01$

this purpose. The first step in this process is to randomly assign the pairs to two groups. The paired differences on each variable are calculated within the two groups. In group 1 ($X_{f\,j}$-X_{fj}) computes the difference on variable j for firm f where firm f is the JIT adopting firm and firm f' is the non-adopting firm. In group 2 (X_{fj}-X_{fj}) computes the difference on variable j for firm f where firm f' is the non-adopting firm. Group one and group two are assigned values of 1 and 0 respectively. If the paired firms are different on the tested variables then the model should appropriately place them in the proper group for the response variable and the sign of the coefficient should be in the predicted direction. The constant term is also dropped from the model as recommended by Hosmer and Lemeshow, 1989: 190.

Table 3 summarizes the logistic test results when the differences are pooled for all three years. The ability to pool the variables rather than test each year individually is an added advantage of the multi variate analysis. Pooling should also capture serial correlations that are expected to occur. That is, as JIT firms go beyond their adoption date measurable results should become more evident.

As indicated in Table 3, the analysis of pooled annual differences supports H1, a difference in ROS at alpha < .08 and H4, a difference in INVR at alpha < .02, but not the other hypotheses. The sign on the cost ratio is not in the hypothesized direction.

TABLE 3 - Logistic Tests

Results - Pooled Sample

(ROS)	H_1: α =.0795
(COST RATIO)	H_2: NS
(INV TURNOVER)	H_3: NS
(INV/SALES)	H_4: α =.019

MODEL SUCCESSFULLY IDENTIFIES

82% OF FIRMS α = .0001

TABLE 4 - Logistic Tests

Results - Annual Sample

POST ADOPTION YEAR			
	ONE	TWO	THREE
H_1:(ROS)			
	α=.05	NS	NS
H_2:(COST RATIO)			
	NS	NS	NS
H_3:(INV TURNOVER)			
	NS	NS	α=.066
H_4:(INV/SALES)			
	NS	α=.073 α=.085	

MODEL SUCCESSFULLY IDENTIFIES FIRMS IN SAMPLE

	91%	77%	92%
α =	.0018	.064	.003

The variables in Table 4 are the differences in rates of change in the variables across firms on a year by year basis. These results support H1, ROS, in year one; H4, INVR, in year two and three; and H3, INVTO in year three only. However, both the pooled LOGIT model and the annual LOGIT model effectively discriminated between JIT and nonJIT firms with high degrees of significance.

The divergence in significance between the pooled model and the annual models on specific variables may be explained in two ways. First, N for the annual models is small which supports reliance on the non-parametric model. And, second, it is not unusual for economic variables to exhibit instability over time. The pooled model does provide support for the significant univariate results on two variables. The cost ratio is insignificantly different across all tests.

The results in this study are magnified by two important considerations. First, it is not possible to be perfectly certain that all control group firms have no JIT applications in place. Given the recent competitive environment, conjecture would lead one to conclude that this presents a possibility. JIT is usually adopted by an individual plant, department and/or division and seldom on a firm wide basis, financial benefits derived from adopting JIT could conceivably be buried in inefficiencies in other areas of the firm. Thus, there is bias against rejecting the null hypotheses. Except for matching, control has not been attempted for firm-specific changes that may not be directly related to the JIT adoption. Therefore, causal relationships can not be inferred from these results.

V. Summary and Limitations

The primary conclusion drawn from this study is that the firms identified have experienced positive changes in operations, in relation to the comparison group, following JIT adoption. Firms in general do not adopt JIT across the entire spectrum of operations but rather plant-wise or division-wise. Therefore strong support of these hypotheses suggests that two things may be occurring: 1) positive results of adoption are strong enough to affect firm wide outcomes and/or 2) JIT at any level within a firm may result in a synergistic change in operations even though many locations or divisions have not adopted the JIT model.

Caution should be used in any effort to extrapolate these results to other samples, firms or settings. This caution needs to be exercised for a variety of limitations imposed by the nature of the study and the nature of the sample. These include a small sample size, survival bias and self-selection bias as well as other limitations addressed throughout the paper.

VI. Conclusion and Recommendations for Future Research

Strong support is found for differential decreases in inventory as a percentage of sales for JIT adopters, and the propositions that JIT leads to higher return on sales. Several conclusions can be drawn from this analysis. First, as is to be expected, firms adopting JIT do appear to benefit in general from the process. Second, JIT adoption leads to cost savings below the gross profit line that can be reflected in an increase in return on sales for the firm as a whole. Whether this result can be directly attributed to JIT adoption or whether it is a reflection of a change in attitude toward all costs effectuated by adopting firms is not clear from this study. Financial outcomes for firms in the study may also be affected by firm specific changes not identified here. Finally, at the firm wide level, results fail to capture astounding levels of cost savings at the product cost level as projected for adopters in the professional literature. This study may have simply failed to capture these savings due to limitations, such savings may not exist or as suspected, savings above the gross profit line may be absorbed in product price changes with the cost ratio remaining fairly constant for adopting firms.

Future research in this area should address any or all of the limitations presented herein. Particularly, an increase in sample size would improve the generalizability of any significant statistical results.

Finally, to capture the true effects of JIT for some firms, analysis should be carried out at the divisional level. Top management may determine that JIT is justifiable and feasible for only a limited number of applications, divisions or departments within a decentralized firm. For these reasons, realization of financial statement effects may not be forthcoming immediately or in every area. Further, the effects of departmental or divisional adoption of JIT by a large firm may not be reflected on company wide financial statements, but, rather, may be "swamped" or buried in the financial performance of other areas of the firm. Therefore, additional analysis could be undertaken between adopting and non-adopting divisions of the same firm. Or, alternatively, the analysis could take place across similar division's of different firms. While the divisional level may be the ideal arena of analysis, divisional data is internal to firms and not often either publicly available or forthcoming on request. Therefore, a field study approach may be necessary to capture this information and to add understanding and meaning to the findings here.

REFERENCES

Ayres, F., "Characteristics of Firms Electing Early Adoption of SFAS 52," *Journal of Accounting and Economics*, v. 8, 1986, pp. 143-158.

Bowen, R.E., E. Noreen and J. Lacey, "Determinants of the Corporate Decision to Capitalize Interest," *Journal of Accounting and Economics*, v. 3, 1981, pp. 151-179.

Braham, J., "The Marriage of Marketing and Manufacturing," *Industry Week*, June 1, 1987, pp. 41-44.

Calvasina, R.V., E.J. Calvasina, and G.E. Calvasina; "Beware the New Accounting Myths," *Management Accounting*, December 1989, pp. 41-45.

Chikkara, J. and Weiss, E.N. "JIT Savings – Myth or Reality", *Business Horizons*, May-June, 1995.

Christie, "On Cross-Sectional Analysis in Accounting Research," *Journal of Accounting and Economics*, December, 1987, pp. 231-258.

Hagerman, R.L. and M. Zmijewski, "Some Economic Determinants of Accounting Policy Choice, *Journal of Accounting and Economics*, v1 1979, pp. 141-161.

Hosmer, D.W. and S. Lemeshow, *Applied Logistic Regression*, John Wiley and Sons, New York, 1989.

McLachlin, R. and C. Piper; "Just-In-Time Production," *Business Quarterly*, Summer 1990, pp. 36-41.

Neter, J., W. Wasserman, and M. Kutner, *Applied Linear Regression Models*, Richard D. Irwin, Inc., Homewood, Illinois, 1989.

O'Boyle, T.F., "Last-in, Right-out," *Wall Street Journal*, November 19, 1990, p. 1 c. 6.

Patell, J.M.; "Cost Accounting, Process Control, and Product Design: A Case Study of the Hewlett-Packard Personal Office Computer Division," *Accounting Review*, October 1987, pp. 808-837.

Phillips, A. and D.E. Collins, "How Borg-Warner Made the Transition From Pile Accounting to JIT", *Management Accounting*, October 1990, pp. 32-35.

Rohan, T., "Factories of the Future," *Industry Week*, March 31, 1988, pp. 33-66.

Schonberger, R., *World Class Manufacturing: The Lesson of Simplicity* Applied, 1986.

_____, *World Class Manufacturing Casebook: Implementing JIT and TQC*, 1987.

Sheriden, J. "America's Best Plants," *Industry Week*, October 15, 1990, p. 47.

Suzaki, K.; "Comparative Study of JIT/TQC Activities in Japanese and Western Companies," First World Congress of Production and Inventory Control, Vienna, Austria, 1985, pp. 63-66.

Wise, R.; "Why Aren't Quality Programs Boosting Industry profits?", *Electronic Business*, March 5, 1990, pp. 39-39.