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JIT performance effects: A research note

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ABSTRACT

This paper uses a sample of 131 just-in-time (JIT) firms and their matched non-JIT firms to examine whether adoption of JIT improves firm performance. Tobin's *Q* and return on assets (ROA) are used to measure firm performance. Overall, the results indicate that statistically significant differences in Tobin's *Q* and ROA were observed in a pre- and post-test of JIT adopters and between matched non-JIT adopters.

1. Introduction

Although interest in Just-in-time (JIT) practices has been increasing for over two decades, empirical studies that examine the relationship between JIT adoption and firm performance are mixed (Anyane-Ntow, 1991; Balakrishnan, Linsmeier, & Venkatachalam, 1996; Fullerton & McWatters, 1999; Huson & Nanda, 1995; Mia, 2000; Ockree, 1993). For example, using a sample from 50 companies for one year, Anyane-Ntow (1991) compares relative firm profitability and inventory levels from each of six industrialized nations; however, his results are inconclusive about the impact of JIT adoption on firm profitability. Balakrishnan et al. (1996), using a matched-pairs design, investigate 46 firms that adopted JIT over the 1985–1989 period and found no significant difference in the changes to return on assets (ROA) between the treatment group and the control group. In fact, both groups reported a decline in their ROA; leading to the conclusion that JIT implementation did not produce better financial performance. Balakrishnan et al. (1996) suggest that the decline they observe in the ROA could also be attributed to the deteriorating economic conditions in the late 1980s. However, Fullerton, McWatters, and Fawson (2001) also examine JIT profitability effects using data from 253 firms, documenting a positive relation between profitability and JIT adoption. Additionally, in an extension of Balakrishnan et al. (1996), Kinney and Wempe (2002) compare the profitability of JIT and non-JIT adopters, finding that JIT positively affects adopters' ROA.

The studies cited above examined firm performance using accounting return on assets rather than a measure of firm performance based on the equity market such as Tobin's *Q*.[1] Thus, the purpose of this study is to extend Kinney and Wempe (2002) to investigate the performance, as measured by Tobin's *Q* and ROA, of JIT adoption through a five-year window. Both Kinney and Wempe (2002) and Balakrishnan et al. (1996) used a three-year window to examine the JIT adoption impact on firm ROA with conflicting results. If Balakrishnan et al. (1996) are correct that competitors of JIT adopting firms will follow by adopting JIT themselves, then five years should be long enough for any positive benefits of JIT by the "first adopters" to begin dissipate. Thus, if there is evidence that JIT is related to firm performance over a five-year period it will support the findings of Kinney and Wempe (2002) and also refute the assertion that competitors in the industry will immediately follow and the performance benefits of JIT adoption will be transitory.

The contribution of this study is to assess a five-year window of JIT performance. The basic premise investigated is that a successful adoption of JIT should result in enhanced firm performance as measured by Tobin's *Q* and ROA on average over a five-year window. This paper provides new insights onto the performance of JIT adoption, thus, it is an important contribution in the presence of continuing interest in JIT implementation.

To test the impact of JIT adoption on firm performance, 131 sample firms[2] of the 201 provided by Kinney and Wempe (2002) are used to investigate the effect of JIT adoption on firm performance. The results indicate significant difference in performance measures (both ROA and *Q*) between pre-adoption and post-adoption periods of JIT adopters and between JIT and non-JIT adopters. In fact, JIT adopters have significantly higher increases in ROA and *Q* than their matched control firms of non-JIT adopters.

In the next section we develop the hypotheses. Section 3 details the measurement and sample selection and screening, while Section 4 reports the study results, and Section 5 reports the self-selection sensitivity results. The final section provides the conclusion and suggestions for future research.

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[1] The economics and finance literature suggest that Tobin's *Q* provides a market estimate of the firm's long-term performance (Smirlock, Gilligan, & Marshal, 1986, Ben-Horim & Callen, 1989).

[2] Complete data for only 131 firms were available through year 5 to compute Tobin's *Q*. For consistency, the 131 firms were used to compute ROA.

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2. Hypotheses

The direct costs associated with excess inventories include storage costs, cost of capital, and the cost of obsolescence. In addition, the presence of excessive inventory levels may also reflect poorly on the ability and competence of the firm's management team and on the effectiveness of the firm's supply chain processes. Thus, carrying excess inventories may signal a lack of coordination and collaboration among supply chain partners as well as a lack of flexibility and agility to adjust to sudden demand shifts. This can result in increasing uncertainty about future earnings and their growth prospects, thereby negatively affecting the reputation of the firm and its market value (Singhal, 2005).

Hendricks and Singhal (2003) investigated the stock market reaction to supply chain problems causing production or shipping delays. Using a sample of 519 announcements made during 1989–2000, they found that the supply chain problems significantly decrease shareholder value. They find market prices react when problems in normal inventory control are large enough to require announcement in the Wall Street Journal and the Dow Jones News Service. However, their study neither indicates whether inefficient inventory control practices that may be reflected in the financial statements, but not otherwise publicly announced, are deemed important to the equity market; nor does it provide information about the importance of the market response to inventory holdings.

Tobin's *Q* is a performance measure that firms and potential investors frequently use to evaluate firm performance. As a performance metric, Lee and Grewal (2004) suggest that Tobin's *Q* has several advantages. First, it is derived from stock market price, which reflects future performance and therefore is a forward-looking measure. Second, Tobin's *Q* reflects a firm's long-term profitability because it captures the relationship between the replacement cost of a firm's tangible assets and the market value of the firm (Bharadwaj, Bharadwaj, & Konsynski, 1999). Third, Tobin's *Q* can be used to compare across industries because it is not affected by accounting conventions (Chakravarthy, 1986).

Tobin (1969) argues that inventory reductions due to JIT implementation will lower inventory carrying costs that, in turn, will improve firm financial position. He further argues that firms highly valued by the equity market will have a high Tobin's *Q*. Therefore, if a JIT firm is highly valued because it leads to lower cost and higher returns, then a JIT firm will have a particularly high Tobin's *Q*.

If efficiencies result, the market for equity securities might view this investment as having a positive net present value and adjust the price of the firms' securities upward (Howton, Higgins, & Biggart, 2000). This is consistent with McConnell and Muscarella (1985) who find that the announcements of capital expenditure are met with positive stock price reactions in the market. This is also consistent with Inman and Mehra (1993) who find evidence to suggest that JIT adoption is correlated with the future financial success of the firm. Thus, if JIT adoption is viewed as beneficial capital expenditure, it will result in increased market prices.

Thus, the association between JIT adoption and firm performance over a longer period provides additional rationale for the use of *Q* and ROA as performance measures in extending prior studies. Consequently, we hypothesize:

H_1 $Q_{POST,\ TRMT} > Q_{PRE,\ TRMT}$

H_2 $Q_{POST,\ TRMT} - Q_{PRE,\ TRMT} > Q_{POST,\ CTRL} - Q_{PRE,\ CTRL}$

H_3 $ROA_{POST,\ TRMT} > ROA_{PRE,\ TRMT}$

H_4 $ROA_{POST,\ TRMT} - ROA_{PRE,\ TRMT} > ROA_{POST,\ CTRL} - ROA_{PRE,\ CTRL}$

Where the subscripts

Q	Tobin's *Q*
ROA	return on assets
PRE	pre-adoption
POST	post-adoption
TRMT	treatment firms
CTRL	control firms

Table 1
Sample selection and screening.

	Sample size
Sample provided by Kinney and Wempe (2002)	201
Firms missing data necessary to calculate Tobin's *Q* in each year from −5 through +5 relative to JIT adoption year	*70*
Final sample (matched pairs)	131

3. Measurement and sample selection

3.1. Measurement

Two measures of firm performance used in this study are ROA (return on assets) and Tobin's *Q*. Although various methods have been proposed for calculating Tobin's *Q*, according to Chung and Pruitt (1994), different approaches tend to yield similar *Q* values. In this study, to calculate Tobin's *Q*, we use the following formula proposed by Chung and Pruitt (1994)[3] which has also been used in prior studies (e.g., see Lee & Tompkins, 1999; Mitra & Rashid, 2002):

$$\text{Tobin}'\text{s}\,Q = (MVE + PS + DEBT)/TA \quad (1)$$

Where

MVE	product of a firm's share price and the number of common stock shares outstanding,
PS	liquidating value of the firm's outstanding preferred stock,
DEBT	book value of the firm's short-term liabilities net of its short-term assets, plus the book value of the firm's long-term debt, and
TA	book value of the total assets of the firm.

We do not calculate the replacement value of tangible assets as proposed by Lindenberg and Ross (1981)[4] because past research has found little qualitative difference between this measure and the version used in this analysis (Chung & Pruitt, 1994; Lee & Tompkins, 1999; Perfect & Wiles, 1994).

The second measure, ROA, is frequently used by researchers as a measure of firm performance (e.g., Balakrishnan et al., 1996; Barber & Lyon, 1996; Barua, Kriebel, & Mukhopadhyay, 1995; Bharadwaj, 2000; Hitt, & Brynjolfsson, 1996; Kinney & Wempe, 2002; Weill, 1992). Since ROA incorporates both firm efficiency and profitability (Skousen, Simmons, McDonald, & Ziemkiewicz, 2002), it tends to be a useful overall performance measure. ROA is computed as income before extraordinary items (available for common stockholders) divided by the average operating assets.

3.2. Sample selection and screening

As in K&W, we matched non-adopting firms to the 201 JIT adopters in the preliminary sample. We matched first on inventory valuation method, and then attempted to match on net sales in the year

[3] According to Chung and Pruitt (1994), approximate q in Eq. (1) explains 96.6% of the variability of Tobin's *Q* obtained by using the Lindenberg and Ross (1981) method.

[4] Lindenberg and Ross (1981) calculate *q* via the following formula: (PREFST + VCOMS + LTDEBT + STDEBT − ADJ) / (TOTASST + BKCAP + NETCAP) where PREFST is defined as the liquidating value of a firm's preferred stock, VCOMS is the price of the firm's common stock multiplied by the number of shares outstanding at the close of the year (December 31), LTDEBT is the value of the firm's long-term debt adjusted for its age structure, STDEBT is the book value of the firm's current liabilities, ADJ is the value of the firm's net short-term assets, TOTASST is the book value of the firm's total assets, BKCAP is the book value of the firm's net capital stock, and NETCAP is the firm's inflation-adjusted net capital stock.

Table 2
Descriptive statistics for 131 JIT adopters and matched control firms.

Panel A: Distribution of JIT adoption years

Year	Number of firms	Percentage
1983	4	3.053
1984	8	6.107
1985	9	6.870
1986	11	8.397
1987	8	6.107
1988	19	14.504
1989	17	12.977
1990	21	16.031
1991	15	11.450
1992	11	8.397
1993	8	6.107
	131	100.000

Panel B: Distribution of two-digit industry classifications

Two-digit industry code	Industry description	Number of firms	Percentage
25	Furniture	6	4.580
27	Printing, publishing	2	1.527
28	Chemicals	3	2.290
30	Rubber and plastics	4	3.053
33	Primary metals	8	6.107
34	Fabricated metals	9	6.870
35	Industrial equipment	29	22.137
36	Electronic equipment	35	26.718
37	Motor vehicles	10	7.634
38	Instrumentation	18	13.740
39	Other manufacturing	2	1.527
50	Wholesale durables	1	0.763
53	Department stores	1	0.763
59	Miscellaneous retail	1	0.763
73	Packaged software	2	1.527
		131	100.000

preceding JIT adoption at the four-digit industry level. If an acceptable match was not available, then we dropped to the three-digit level and, if necessary, to the two-digit level (Table 1).

Next, we align the annual data of each treatment firm and its matched non-adopter in event time based on the adoption year (year 0). However, we define the pre- (post) adoption period to be five years preceding (following) adoption. This led to a complete data for only 131 firms to compute Tobin's *Q*. For consistency, the 131 firms were used to compute ROA.

Table 2, Panel A summarizes the temporal distribution of the 131 treatment firms used in the study. Table 2, Panel B provides the two-digit industry distribution for the treatment and matched control firms. As in Kinney and Wempe (2002), firms are mainly represented in industries 35 and 36 (Industrial Equipment and Commercial Machinery [including computers] and Electronic Equipment, respectively) with 48.8% of all firm-pairs in our sample compared to 43% in Kinney and Wempe (2002).

3.3. Sample validation

We use one-tailed *t*-tests for sample validation. As shown in Fig. 1, treatment firms have significantly improved their total inventory

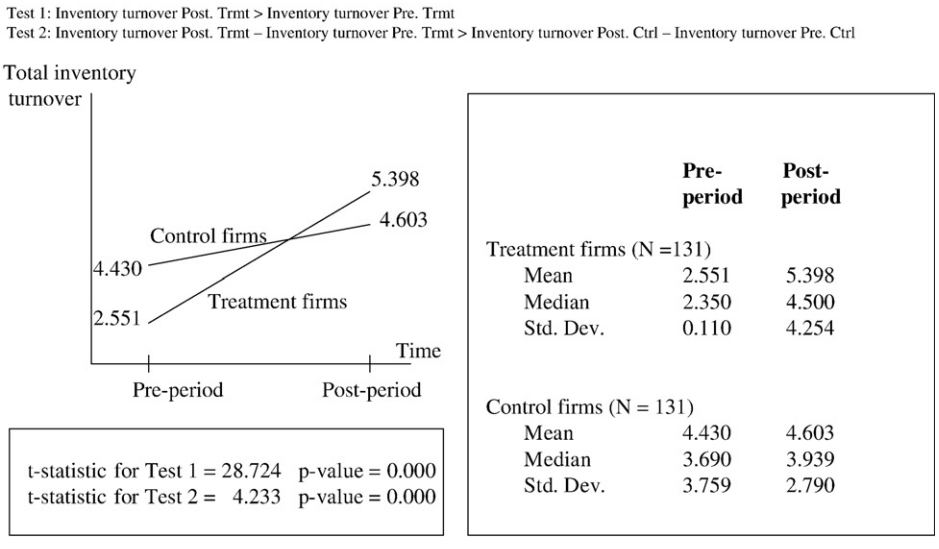
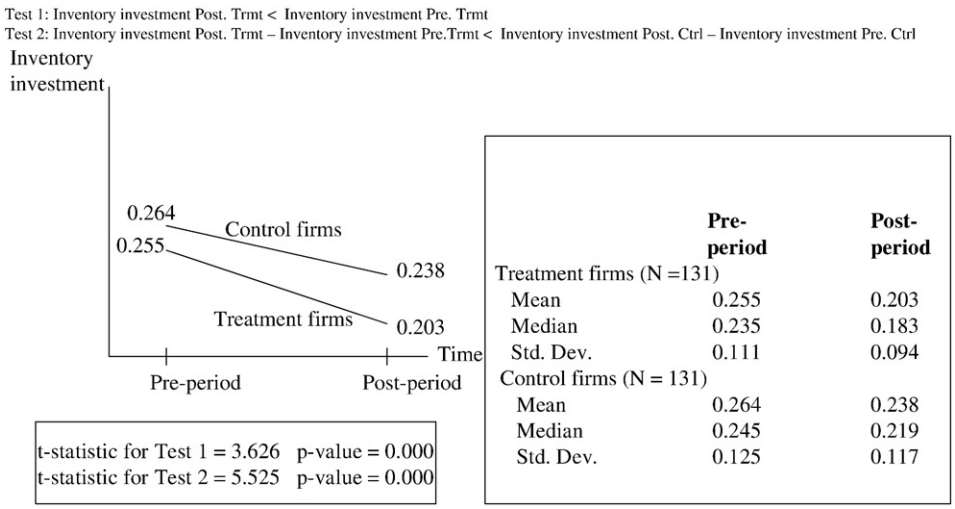


Fig. 1. Sample validation tests of inventory turnover (cost of sales/average total inventory).



	Pre-period	Post-period
Treatment firms (N =131)		
Mean	0.255	0.203
Median	0.235	0.183
Std. Dev.	0.111	0.094
Control firms (N = 131)		
Mean	0.264	0.238
Median	0.245	0.219
Std. Dev.	0.125	0.117

Fig. 2. Sample validation tests of inventory investment (inventory/total assets).

turnover (cost of sales/average total inventory) from the pre- to post-adoption periods ($p = 0.000$). Also, relative to control firms, treatment firms have experienced a significant incremental gain in total inventory turnover ($p = 0.000$).

As reported in Fig. 2, the test for inventory investment (inventory/total assets) indicates that treatment firms have significantly decreased their inventory investment from the pre- to post-adoption periods ($p = 0.000$). Also, relative to control firms, treatment firms have experienced a significant decrease in inventory investment ($p = 0.000$).

4. Results

4.1. Descriptive statistics

For each firm, we assess a pre- (post) adoption variable as its mean (median) value for the five-year pre- (post) adoption period. Table 3 provides descriptive statistics of firm attributes in the pre-adoption period for both the treatment and the control samples in terms of mean, median and significance as reflected in the *t*-statistics for mean difference and Wilcoxon *z*-statistic for median difference. As reported in the first two columns, the mean (median) average assets, average investment and average equity differences are large and statistically significant, indicating that JIT adopters are, on average, larger than their non-adopting matched firms, supporting Kinney and Wempe (2002). But the mean (median) sales growth and return on assets differences are not statistically significant.

4.2. Hypotheses test

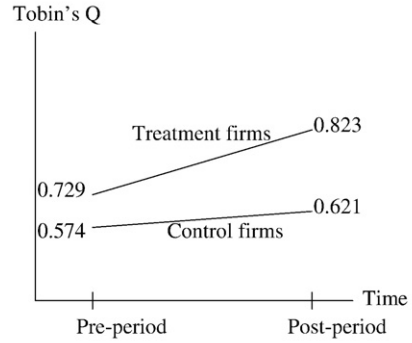
We test H_1 and H_2 with one-tailed *t*-tests. As indicated in Fig. 3, treatment firms' Q increase an average of 12.89% ([0.823 − 0.729]/0.729) from the pre- to post-adoption ($p = 0.006$), while Q increased only by 8.19% for the match sample during the same period. The effect of the increase in Q also results in significant gains for the treatment sample relative to the matched control sample ($p = 0.027$). Thus, the results show that, on average, JIT firms improve their performance as measured by Q. Therefore, both H_1 and H_2 are supported.

Similarly, the results of our tests for ROA (i.e. H_3 and H_4) show that, as indicated in Fig. 4, treatment firms' ROA increase an average of 21.12% from the pre- to post-adoption ($p = 0.071$), while ROA increased only by 7.018% for the match sample during the same period. Therefore, H_3 is supported. The results also indicate that the increase in treatment firms' ROA (from pre- to post-adoption) is significantly higher than that of the matched control firms during the

Table 3
Distribution of mean and median sample data and comparison of treatment and control firms in the pre-adoption period ($n = 131$ pairs).

Firm attributes	Mean ($ mil or ratio)	Median ($ mil or ratio)	Std. dev. ($ mil or ratio)	*t*-statistic (difference in means)	Wilcoxon *z*-statistic (difference in medians)
Average assets (millions)					
Treatment	1817.190	304.724	5044.310	3.856	8.055
Control	903.240	153.753	2509.323	(0.000)	(0.000)
Average investment (millions)					
Treatment	381.900	77.920	980.463	3.863	8.023
Control	200.140	37.626	538.120	(0.000)	(0.000)
Average equity (millions)					
Treatment	866.810	136.580	2758.613	4.230	7.732
Control	349.550	69.143	915.922	(0.000)	(0.000)
Sales growth					
Treatment	0.119	0.091	0.238	−1.139	−0.236
Control	0.139	0.089	0.360	(0.255)	(0.407)
ROA					
Treatment	0.051	0.062	0.070	1.709	2.658
Control	0.048	0.058	0.073	(0.103)	(0.139)

Test 1: Tobin's Q Post. Trmt > Tobin's Q Pre. Trmt
Test 2: Tobin's Q Post.Trmt – Tobin's Q Pre.Trmt > Tobin's Q Post. Ctrl - Tobin's Q Pre. Ctrl



	Pre-period	Post-period
Treatment firms (N =131)		
Mean	0.729	0.823
Median	0.612	0.687
Std. Dev.	0.591	0.713
Control firms (N = 131)		
Mean	0.574	0.621
Median	0.493	0.547
Std. Dev.	0.571	0.516

t-statistic for Test 1 = 2.913 p-value = 0.006
t-statistic for Test 2 = 2.401 p-value = 0.027

Fig. 3. Test of changes in Tobin' *Q*.

same period ($p = 0.043$). Thus, in support of H_4, our results show that, on average, JIT adopters' ROA increase relative to control firms' ROA.

5. Self-selection sensitivity test

The above tests ignore self-selection bias that may be inherent in the JIT adoption decision. Hence, if the underlying firm characteristics that prompt JIT adoption are also associated with superior future performance (without regard to JIT's performance effects), then the above tests of paired differences in changes in Tobin's *Q* may overstate JIT's performance effects. To evaluate the effects of endogeneity on our H_2 inferences, we followed K&W to conduct a two-stage self-selection analysis. In the first stage, we use a probit model to estimate the following model:

$$ADOPT_j = \beta_0 + \beta_1 INNOVATE_j + \beta_2 PRE\_SALES_j + \beta_3 VAR\_DEMAND_j + \beta_4 PRE - INVTURN_j + \mu_j \quad (2)$$

where:

ADOPT 1 if firm *j* is a JIT adopter, and 0 otherwise;

INNOVATE firm innovativeness, proxied by median R&D/Sales in the pre-adoption period;

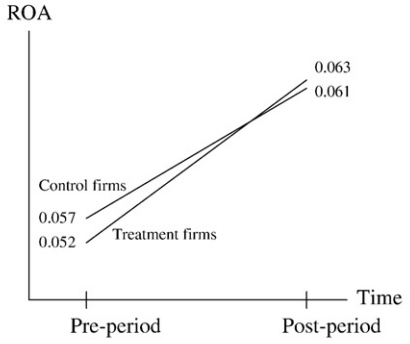
PRE_SALES median sales in the pre-adoption period;

VAR_DEMAND variability of demand for the firm's output; and

PRE INVTURN_median total inventory turnover in the pre-adoption period.

As in K&W, we include INNOVATE to reflect the possibility that innovative firms, proxied by R&D spending scaled by sales, may be more likely to adopt new technologies. We include PRE_SALES because average firm size differs between samples, and because firms with greater resources may be more inclined to adopt new technologies. We include VAR_DEMAND because JIT may be less beneficial to firms for which product demand (and thus production and input demand) is more variable. To estimate VAR_DEMAND, we regress a firm's cost of sales for the 40 quarters preceding JIT adoption on a quarterly time-trend variable. VAR_DEMAND is the standard deviation of the regression residuals, scaled by mean cost of sales over the estimation period. We include PRE_INVTURN because managers of firms with low inventory turnover may anticipate the greatest benefits from JIT adoption

Test 1: ROA Post. Trmt > ROA Pre. Trmt
Test 2: ROA Post.Trmt – ROA Pre.Trmt > ROA Post. Ctrl - ROA Pre. Ctrl



	Pre-period	Post-period
Treatment firms (N =131)		
Mean	0.061	0.057
Median	0.059	0.055
Std. Dev.	0.053	0.051
Control firms (N = 131)		
Mean	0.063	0.052
Median	0.054	0.046
Std. Dev.	0.061	0.073

t-statistic for Test 1 = 2.013 p-value = 0.071
t-statistic for Test 2 = 2.617 p-value = 0.043

Fig. 4. Test of changes in ROA.

Table 4
Results of two-stage self-selection analysis.

Stage 1: JIT Choice Model (Eq. (2)) [Probit model] $ADOPT_j = \beta_0 + \beta_1 INNOVATE_j + \beta_2 PRE\_SALES_j + \beta_3 VAR\_DEMAND_j + \beta_4 PRE - INVTURN_j + \mu_j$

	Estimated coefficient	*p*-value
INTERCEPT	−0.091	0.823
INNOVATE	2.136	0.417
PRE_SALES	0.002	0.097
VAR_DEMAND	−0.514	0.413
PRE_INVTURN	−0.092	0.670
Model significance: 0.036		

Stage 2: Model Incorporating Selectivity Variables (Eq. (3)) $\Delta Q = \alpha_0 + \alpha_1 INNOVATE + \alpha_2 PRE\_SALES + \alpha_3 VAR\_DEMAND + \alpha_4 PRE\_INVTURN + \alpha_5 M_{J(C)} + \varepsilon$

	Adopters		Non-adopters	
	Estimated coefficient	*t*-statistics	Estimated coefficient	*t*-statistics
INTERCEPT	−0.053	−0.971	−0.191	−0.379
INNOVATE	0.108	0.710	−0.810	−0.418
PRE_SALES	0.001	2.693	−0.002	−0.431
VAR_DEMAND	0.003	1.035	0.027	−0.083
PRE_INVTURN	−0.012	−1.173	0.001	0.034
$M_{J(C)}$	−.049	−0.687	0.194	0.361
Model R^2		0.031		0.042

(Balakrishnan et al., 1996). Finally, we estimate the model with samples matched on industry, inventory method, and size.

The results of the two-stage self-selection are presented in Table 4. In the first stage, the coefficients of PRE_SALES and INNOVATE are significant ($p = 0.050$ and 0.010, respectively). In addition, the model is significant at the 0.001 level. In the second stage, we estimated, separately for the two samples, the following model:

$$\Delta Q = \alpha_0 + \alpha_1 INNOVATE + \alpha_2 PRE\_SALES + \alpha_3 VAR\_DEMAND + \alpha_4 PRE\_INVTURN + \alpha_5 M_{J(C)} + \varepsilon \quad (3)$$

where Q, INNOVATE, PRE_SALES, VAR_DEMAND, and PRE_INVTURN are as previously defined, and M_J and M_C are selectivity variables. In the adopter equation, M_J is $-f(\beta'Z)/F(\beta'Z)$; for non-adopters, M_C is $f(\beta'Z)/[1-F(\beta'Z)]$, where $f(\bullet)$ and $F(\bullet)$ are the density and distribution functions, respectively, of the standard normal distribution, and $\beta'Z$ is the prediction from the first-stage probit model.

We assess selection bias by examining the estimates of α_5 in the two equations. If $\alpha_5 < 0$ in both equations, then our primary results overstate JIT's Q effect because ΔQ is overstated for the adopter sample and understated for the control sample. However, the coefficients of M_J and M_C, reported in the second stage, are negative and positive, respectively, and not significant at conventional levels. Thus, the analysis provides no evidence that self-selection bias affects our inferences.[5]

6. Conclusion

The purpose of this study is to provide further explanations to JIT success. The first contribution of this paper is that it adds to the growing literature on JIT adoption by introducing a performance measure, Tobin's Q, to assess the performance effect of JIT adoption. More specifically, this study uses a sample of JIT adopters and matched non-adopters obtained from Kinney and Wempe (2002) to examine the effect of JIT adoption on firm value as measured by Tobin's Q. The second contribution of the study is to revisit Kinney and Wempe (2002) and Balakrishnan et al. (1996) and assess JIT–ROA relationship over a five-year window.

Results indicate that within the same five-year pre- and post-adoption windows, comparison across treatment and control samples shows that treatment firms have significantly higher increase in Q than their matched control firms. The results are consistent with the cost of capital hypothesis that suggests that the market views JIT adoption as having a positive effect on firm value (McConnell & Muscarella, 1985). Also, overall, JIT adoption does lead to improvement in firm performance as measured by ROA, providing support for Kinney and Wempe's (2002) three-year window findings.

The results of this research are important to both managers who have implemented JIT or contemplate the JIT adoption. The results can also provide insight to investors who are deciding which companies to invest in and how JIT adoption might affect firm performance.

As in K&W, our self-selection bias analysis relies on an untested model of JIT choice. Thus, we cannot rule out the possibility that our reported results stem at least partially from underlying dissimilarities between JIT adopters and non-adopters. Also, further research needs to be done on whether the results were more oriented to particular industries, or firm characteristics such as managerial and institutional ownership of the firm, and the extent of competition faced by the firm. Finally, as more companies globalize their operations, it would be valuable to use a global sample of firms to determine to what extent firm value effect of JIT adoption can be generalized.

[5] Similar sensitivity analysis was performed for ROA. Results indicate no self-selection bias. Results are available from first author upon request.

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