The Effects of Firm Efficiency and Production Decisions on Inventory Write-Down: Evidence from Taiwanese Manufacturing Companies

Yee Chuann Chan, Qian Long Kweh and Wei-Kang Wang

Abstract: This purpose of this study is to examine the determinants of inventory write-down decisions including firm efficiency and production decisions. Data envelopment analysis (DEA) is used to proxy for firm efficiency while change in percent added to inventory (CPAI) is used to proxy for overproduction. We utilize Taiwanese manufacturing companies listed on Taiwan Stock Exchange (TWSE) and with data available in Taiwan Economic Journal (TEJ) database as the sample in this study. Results show that firm efficiency has significant positive relationship with inventory write-down indicating managers exercise reporting flexibility to engage in accrual manipulation. However, we do not find significant association between overproduction and inventory write-down to support the real earnings management hypothesis.

Key words: Inventory write-down • Data envelopment analysis (DEA) • Overproduction • Accrual manipulation and real earnings management

INTRODUCTION

It has been widely recognized that inventory write-down amounts and timing are less likely to be opportunistic because ready market value and clear authoritative guidance limit managers’ discretions [1-3]. Nevertheless, inventory write-down, in spite of the little discretion given to management, is under great scrutiny by the regulators. U.S. Securities and Exchange Commission (SEC), in fact, in the Accounting and Auditing Enforcement Releases (AAERs) between April 1982 and April 1989 revealed and detected 70% of registrants overstated the inventory and accounts receivable [4]. In a more recent AAER No. 2006, for example, the Warnaco Group, Inc. overstated inventory by over 100 percent in its largest division and 20 percent in the whole company amounting to US$159 million from 1996 till early 1999. From these evidences, it is clear that opportunistic managers are still able to exercise their limited discretions in the inventory write-down decision by accrual manipulation to mislead investors despite the clear authoritative guidance. This frequent and large magnitude inventory overstatements motivate us to investigate the determinants of inventory write-down decisions.

However, another stream of argument links the real earnings management in inventory production decisions to inventory write-down in the next period [5]. It is argued that managers might distort income by engaging real earnings management in the form of adding inappropriate changes to production. Overproduction is alleged opportunistic because current year earnings could be inflated by capitalizing part of the fixed manufacturing overhead (FMO) into ending inventory under absorption costing [5,6].

In contrast to opportunism, inventory write-down could be a signal conveyed by the managers regarding the deteriorating performance of the firm. Larson, Turcic and Zhang [7] provide empirical evidence on the declining firms’ financial performance and market adjusted return of firms experiencing inventory write-down. Hence, the write-down decisions would be driven by the firms’ financial performance or firm efficiency. In other words, there is association between inventory write-down and firm efficiency.

1 Further information could be obtained from SEC website: http://www.sec.gov/litigation/admin/34-49677.htm
2 It is management actions to manipulate earnings through real activities that affect cash flows [13].
3 Absorption costing is an inventory valuations that are inclusive of manufacturing overhead under [14].

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We use data envelopment analysis (DEA) score as a proxy for firm efficiency in explaining the inventory write-down decisions. DEA is a mathematical programming approach in efficiency evaluations that incorporates multiple inputs and multiple outputs [8]. Feroz, Kim, and Raab [9] argue that DEA, a consistent efficiency measure, can complement the traditional financial ratios as it overcomes the limitation of using one ratio at one time and problematic interpretations arising from conflicting ratios. Besides, Seiford and Zhu [10] and Luo [11], studying banking companies, apply DEA to measure firm financial performance. While previous study [7] used return on assets as the financial performance measure, this study, however combines various input and output variables to measure the firm efficiency score that serves as proxy for financial performance. Bao and Bao [12] report that firms with better inventory planning (measured by the association between percentage change in cost of goods sold (COGS) and lag one percent of production added to inventory) have stronger association between earnings and firm value. Based on the previous arguments, this study aims to determine whether inventory write-down decisions are driven by firm efficiency and/or earnings management, which includes both accrual manipulation and real earnings management through production decisions.

The rest of this paper is organized as follows. Section 2 reviews the prior literatures and develops the hypotheses. Section 3 presents the research methodology while Section 4 shows the empirical results. Finally, conclusion is presented in section 5.

Literature Review and Hypotheses Development: There are relatively few research examining the determinants of inventory write-down in the past due to its relatively higher liquidity and ready market price [3]. Yet, stock market reactions to inventory write-down announcements are significantly negative due to the income-decreasing effects [1]. Larson, et al. [7] investigate the effects of sales growth and purchasing policy on inventory write-down and their findings suggest that extreme sales growth causes future inventory write-down but purchasing policy does not have significant association with inventory write-down.

Most of the asset write-down literature, which are also relevant and applicable to inventory write-down, focus on long-term asset and goodwill write-down or impairment. The motives for asset impairment are mixed. On one hand, impairment is intended to reflect firm future cash flows consistent with reporting incentive. On the other hand, there are rooms for managers to behave opportunistically in exercising their discretions on the impairment decision.

Write-down in goodwill has negative relationship with future investment opportunities which reflect managers’ intention to reveal private information to financial statements users [15]. Moreover, Aboody, Barth, and Kasznik [16] show that impairment reversal of fixed assets predicts future operating income and cash flows. Using the sample of inventory write-down firms, Larson, et al. [27] found that the sample firms have negative 15.4 percent in return on assets and thus we expect a negative relationship between firm efficiency and inventory write-down.

Previous research on asset write-down applied traditional ratios that sometimes provide conflicting interpretations based on different ratios selected [8] and single measure is unable to characterize the complex organizational performance [17]. This motivates us to examine the link between firm efficiency and inventory write-down to fill the void of management incentives in inventory write-down decision by using DEA that has the advantages of capturing multiple inputs and multiple outputs simultaneously; and it develops the interaction of inputs and outputs into a single measure, which complements the weakness in traditional financial ratios [9,18].

There are numerous studies that employ DEA as performance measures. DEA, a nonparametric frontier estimation technique, is extensively used and widely accepted as a performance measurement in the academic literature [19,20]. DEA can be used in both non-profit organizations and profit-organizations. It has been widely applied to industry like defense department [19], hospital [21], insurance company [22], bank [10], audit firm [23] and manufacturing firm [24,25]. Lu and Hung [26] study the operating performance of Taiwanese semiconductor industry; DüzakIn and DüzakIn [27] analyze the performance of 500 major industrial enterprises in Turkey while Thore, et al. [24] examine the productive efficiency of US computer manufacturers.

In an opportunistic perspective, managers use assets write-down to engage big bath, viz. to write-down more assets during loss period in order to increase the probability of future profits [3]. On another angle of opportunism, firms approaching violations of debt covenants tend to reverse impairment loss to smooth income and thus supporting the “cookie jar” reserve hypothesis [28]. Similarly, managers could delay or avoid writing down assets to inflate or overstate earnings as in
the case of aforesaid Warnaco Group, Inc. AAER. These earnings manipulations are accrual manipulations without cash flows consequences [13]. Under this argument, we expect a positive relationship between firm efficiency and inventory write-down decisions.

Due to the contrasting arguments on the reporting incentive and accrual manipulation incentive, we develop the two-tailed hypothesis in alternate form as follows.

- H1 Firm efficiency is associated with inventory write-down.

The other branch of prior inventory-related earnings management literature shows that management engages real earnings management through production decisions to inflate earnings which is dissimilar with accrual manipulation. Under absorption costing, producing in excess of current demand allows the FMO to be allocated to ending inventory thereby reducing the COGS. This leads to increase in current earnings at the expense of future earnings and such overproduction causes excessive inventory holding costs and higher obsolescence in the next period and thus might increase the inventory write-down [5,13,29].

Disproportionate increase in production is two-sided as it could be good news or bad news. On the one hand, it could be due to management anticipation of future sales hike. On the other hand, it would imply greater inventory write-down in future due to excessive build-up of prior period slow-moving inventory [29]. Research findings on overproduction as a way of real earnings management are mixed. Jiambalvo, et al. [6] find evidence on the significant positive association between market reaction and change in percent of production added to inventory (CPAI). This implies that investors regard CPAI of conveying useful information about future firm performance. Yet they also detect some indication of managers using CPAI for income smoothing purposes. In an extended study, Gupta, et al. [5] provide support that firms with greater earnings management incentive have declining ROA following the year of inventory overproduction despite the higher ROA in the year before. However, there is lack of empirical study focusing on the relationship between production decisions and inventory write-down and this reason prompts us to test the association between inventory overproduction and inventory write-down.

Based on previous arguments, inventory overproduction could be opportunistic or in anticipation of future sales. The former might lead to greater inventory write-down in current period [5] whereas the latter association with inventory write-down is unknown. It is unclear whether we should expect a relation between inventory overproduction and inventory write-down and thus we develop the following two-tailed hypothesis.

- H2 Inventory overproduction is associated with inventory write-down.

**Research Methodology**

**Sample Selection:** Our sample period covers year 2003-2010. We restrict the sample to manufacturing firms listed on TWSE and with data available in TEJ Database. Since some of the variables require two years lagged data, our data cover 2001-2010. Manufacturing firms are chosen because inventory represents a material asset in this industry [6]. The initial sample consists of 4,472 firm-year observations. To mitigate the possible confounding effect of the issuance of Taiwan Revised Statement of Financial Accounting Standard No. 10 “Inventories” (SFAS 10)\(^4\), we exclude 1,116 observations which fall in the transition period, 2008 and 2009, to reduce self-selection bias and the bias arising from certain lagged variables that cover two time regimes within a single observation [3]. This results in a total of 3,356 observations in the final sample. The total samples are partitioned into 747 write-down observations and 2,609 non-write-down observations.

**DEA Scores:** We use Banker, Charnes and Cooper (BCC) model to develop the DEA scores to proxy for firm’s relative efficiency (EFF) as it does not have restriction on constant returns to scale on the inputs and outputs selected [30]. The input-oriented BCC model used in this study for \(n\) DMUs, \(m\) outputs and \(s\) inputs is as follows:

\[
\begin{align*}
\text{Min } & \text{EFF} \\
\text{Subject to:} & \\
\sum_{j=1}^{m} w_j O_{ij} & \geq O_{kj}, j = 1, 2, \ldots, m \\
\sum_{i=1}^{n} w_i I_{jr} & \leq \text{EFF } I_{kr}, r = 1, 2, \ldots, s \\
\sum_{i=1}^{n} w_i & = 1
\end{align*}
\]

\(^4\) In Taiwan, the Financial Accounting Standards Committee (FASC) has adopted the Revised SFAS 10 effective from January 1, 2009 with early adoption permissible as an initiative to move in line with the International Financial Reporting Standards (IFRS).
where:

\[ \text{EFF} = \text{DEA scores}; \]
\[ O_{ij} = \text{Output } j \text{ for DMU } i; \]
\[ I_{ir} = \text{Input } r \text{ for DMU } i; \]
\[ O_{ik} = \text{Output } j \text{ for DMU } k \text{ (target DMU)}; \]
\[ I_{ir} = \text{Input } r \text{ for DMU } k \text{ (target DMU)}; \]
\[ w_i = \text{Weight assigned by DEA} \]

Inputs and outputs need to be selected to derive the DEA scores. The two considerations in the inputs and outputs selection are the production function nature and the financial analysis nature of research study [19]. We select total assets (TA), property, plant and equipment (PPE), COGS and number of employees (EMP) as inputs while net income (NI), cash flows from operations (CFO) and sales as outputs [9, 19, 24]. TA represents the net book value of all resources devoted to a company at the end of fiscal year while PPE captures the total investment in tangible assets. COGS measures the resources to produce product in the ordinary business activities while EMP represents the non-financial input in the firm operations. NI is the after tax profit that measure the profitability, CFO reveals the liquidity and cash generated from operations while sales shows the revenue obtained from the business activities. The \( \text{EFF} \) takes the value from 0 to 1 and the closer to 1 signifies higher efficiency.

Regression Models: We use the following logistic regression to test Hypothesis 1 and Hypothesis 2, similar to Francis, et al. [1] and Riedl [3].

\[
W_{d_i} = \lambda_0 + \lambda_1\Delta\text{INDROA}_{i,t} + \lambda_2\text{Sales}_{i,t} + \lambda_3\text{INV}_{i,t} + \lambda_4\text{BATH}_{i,t} + \lambda_5\text{SMOOTH}_{i,t} + \lambda_6\text{DEBT}_{i,t} + \lambda_7\text{ISS}_{i,t} + \lambda_8\text{EFF}_{i,t} + \lambda_9\text{CPAI}_{i,t} + \lambda_{10}\text{FAI}_{i,t} + \lambda_{11}\text{CPAI}_{i,t}\text{*FAI}_{i,t} + \sum_i
\]

(2)

The dependent variable in Model 2 is \( WD_{d_i} \), an indicator variable equal to 1 for firm with inventory write-down, divided by total assets at the end of fiscal year \( t-1 \), greater than 0.5% of total assets at the end of fiscal year \( t-1 \) and 0 otherwise. The variables of interest are \( \text{EFF}_{i,t} \) and \( \text{CPAI}_{i,t}\text{*FAI}_{i,t} \) is firm \( i \)'s relative efficiency scores for the fiscal year \( t-1 \). \( \text{CPAI}_{i,t}\text{*FAI}_{i,t} \) is firm \( i \)'s interaction of change in percent of production added to inventory and fixed asset intensity for the fiscal year \( t-1 \) to proxy for overproduction [5, 6]. Lagged variables are used because write-down decisions would be affected by historical performance. The build-up of slow-moving inventory is as a result of poor prior period performance or when opportunistic overproduction is not matched by future sales and the unsold products become obsolete and has to be written off in future [5].

We expect the coefficient of \( \text{EFF}_{i,t} \) to be negative if economic incentive dominates inventory write-down decisions because poor prior performance causes write-down in current period. On the other hand, if managements delay inventory write-down opportunistically for accrual manipulation, the coefficient should be positive. If real earnings management present, the coefficient on overproduction, \( \text{CPAI}_{i,t}\text{*FAI}_{i,t} \), should be positive because producing in excess of current demand causes excessive inventory holding costs and higher chance of inventory obsolescence [5, 13]. However, if the overproduction is in anticipation of increasing future sales demand, the relationship between overproduction and inventory write-down could be insignificant [29].

Our model controls for the effects of other factors that are likely to affect inventory write-down decisions: change in industry ROA, lagged sales, inventory turnover, big bath, income smoothing, debt ratio and public securities issuance. \( \Delta\text{INDROA}_{i,t} \), \( \text{Sales}_{i,t} \) and \( \text{INV}_{i,t} \), are the control variables for economic incentive. Lagged ROA is firm \( i \)'s industry return on assets for the fiscal year \( t-1 \). This variable controls for industry effects that influence the write-down. We expect the coefficient to be negative because the declining performance will cause more write-down. Similarly, declining prior sales increase the chances of slow-moving stocks and hence more write-down in current period. Inventory turnover measures the movement of inventory and we expect a negative coefficient of this variable.

The remaining control variables are to capture the reporting incentive. \( \text{BATH}_{i} \) is the proxy for “big bath” reporting, equal to the change in firm \( i \)'s pre-write-down earnings from fiscal year \( t-1 \) to \( t \), divided by total assets at the end of fiscal year \( t-1 \), when below the median of nonzero negative values of this variable and 0 otherwise. \( \text{SMOOTH}_{i} \), is the proxy for “earnings smoothing” reporting, equal to the change in firm \( i \)'s pre-write-off earnings from period \( t-1 \) to \( t \), divided by total assets at the end of \( t-1 \), when above the median of nonzero positive values of this variable, 0 otherwise. \( \text{DEBT}_{i} \) is firm \( i \)'s debt to equity ratio for the fiscal year \( t \). Lastly, \( \text{ISS}_{i} \) is an indicator variable equal to 1 if firm \( i \) has public shares issuance in fiscal year \( t \) and 0 otherwise.
Table 1: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Write-Down Observations (n=747)</th>
<th>Non-Write-Down Observations (n=2,609)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
</tr>
<tr>
<td>INDROA_{i,t}</td>
<td>-0.30</td>
<td>-1.02</td>
</tr>
<tr>
<td>Sales_{i,t}</td>
<td>6.59***</td>
<td>6.57</td>
</tr>
<tr>
<td>INVT_{i,t}</td>
<td>6.38***</td>
<td>5.09</td>
</tr>
<tr>
<td>BATH_{i,t}</td>
<td>-0.02***</td>
<td>0.00</td>
</tr>
<tr>
<td>SMOOTH_{i,t}</td>
<td>0.05***</td>
<td>0.02</td>
</tr>
<tr>
<td>DEBT_{i,t}</td>
<td>58.25***</td>
<td>36.41</td>
</tr>
<tr>
<td>ISS_{i,t}</td>
<td>0.29***</td>
<td>0.00</td>
</tr>
<tr>
<td>EFF_{i,t}</td>
<td>0.77***</td>
<td>0.79</td>
</tr>
<tr>
<td>CPAI_{i,t}</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>FAI_{i,t}</td>
<td>0.23***</td>
<td>0.16</td>
</tr>
<tr>
<td>CPAI_{i,t}*FAI_{i,t}</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

***, **, * denotes significance at < 0.01, < 0.05 and < 0.10 levels, respectively, for two-tailed t-tests of differences in means.

Table 2: Logistic Regression: The Determinants of Inventory Write-down

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 2a Coefficient (Z-statistic)</th>
<th>Model 2b Coefficient (Z-statistic)</th>
<th>Model 2c Coefficient (Z-statistic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INDROA_{i,t}</td>
<td>-0.467 (1.139)</td>
<td>-1.059(5.409)**</td>
<td>-0.721 (2.446)</td>
</tr>
<tr>
<td>Sales_{i,t}</td>
<td>-0.052 (30.426)***</td>
<td>-0.047(24.503)***</td>
<td>-0.046 (22.954)***</td>
</tr>
<tr>
<td>INVT_{i,t}</td>
<td>-0.141 (4.504)**</td>
<td>-0.196 (8.466)**</td>
<td>-0.142 (4.294)***</td>
</tr>
<tr>
<td>BATH_{i,t}</td>
<td>-0.026 (4.848)***</td>
<td>-0.033 (12.907)***</td>
<td>-0.028 (9.859)***</td>
</tr>
<tr>
<td>SMOOTH_{i,t}</td>
<td>-0.421 (0.108)</td>
<td>-0.932 (0.523)</td>
<td>-0.416 (0.102)</td>
</tr>
<tr>
<td>DEBT_{i,t}</td>
<td>6.386 (29.719)***</td>
<td>5.689 (23.868)***</td>
<td>5.878 (24.913)***</td>
</tr>
<tr>
<td>ISS_{i,t}</td>
<td>0.000 (1.337)</td>
<td>0.001 (1.644)</td>
<td>0.001 (2.657)</td>
</tr>
<tr>
<td>EFF_{i,t}</td>
<td>0.276 (8.377)***</td>
<td>0.270 (7.951)***</td>
<td>0.287 (8.867)***</td>
</tr>
<tr>
<td>CPAI_{i,t}</td>
<td>1.350 (23.860)***</td>
<td>0.729 (5.768)**</td>
<td>0.576(1.357)</td>
</tr>
<tr>
<td>FAI_{i,t}</td>
<td>-0.146 (1.296)</td>
<td>-0.995 (26.405)***</td>
<td>0.576(1.357)</td>
</tr>
<tr>
<td>CPAI_{i,t}*FAI_{i,t}</td>
<td>0.0043</td>
<td>0.054</td>
<td>0.067</td>
</tr>
</tbody>
</table>

***, **, * denotes significance at < 0.01, < 0.05 and < 0.10 levels, respectively, for one-tailed and two-tailed tests.

We expect negative coefficient on SMOOTH_{i,t} and DEBT_{i,t} and ISS_{i,t}. It is because additional earnings management incentives arise for firms issuing public securities [31], to smooth income and avoid violations of debt covenants as inventory write-downs cause income-decreasing effects. In contrast, we expect the variable, BATH_{i,t}, has positive relationship with inventory write-down because firms with loss position are more likely to write-down inventory to take a big bath [3].

Empirical Results: Table 1 provides the descriptive statistics. The observations are partitioned into write-down (747 observations) and non-write-down (2,609 observations). Write-down firms have lower operating performance, lower prior sales and lower inventory turnover. However, the efficiency score of write-down firms are slightly higher. Moreover, there is no difference in the CPAI_{i,t} between the write-down and non-write-down observations.

Table 2 presents the logistic regression analysis examining the determinants of write-down decisions, with an explanatory power of 6.7% in Model 2c. In Model 2b, the coefficient of EFF_{i,t} (Z-statistic = 23.860) is positive and statistically significant supporting the prediction on managers engaging accrual manipulation and thus supporting H1. The coefficient on CPAI_{i,t} * FAI_{i,t} (Z-statistic = 1.357) in Model 1c is positive but insignificant providing weak support for the prediction on H2. The insignificant association between overproduction and inventory write-down suggests that firms could overproduce to meet higher future sales [6] instead of to inflate earnings. The coefficients on
\[ \Delta \text{INDROA}_{t,i}, \text{Sales}_{t,i}, \text{INVT}_{t,i} \] are significantly negative implying write-down firms have lower operating performance, lower sales and lower inventory turnover.

**CONCLUSIONS**

This paper examines the effects of firm efficiency and production decisions on inventory write-down decisions. Regression results show that firms engaged in accrual manipulation in inventory write-down while overproduction does not affect inventory write-down decision suggesting firms overproduce in anticipation of high future sales.

We contribute to the application of DEA score as a complement to traditional financial ratios in firm performance evaluation. In addition, this study also contributes to the existing literature by linking the earnings management on both accrual manipulation and real earnings management to inventory write-down decisions. Future research can focus on the predictability of inventory write-down decisions. In addition, further studies could examine the long-term performance of firms that write-down inventory.

**REFERENCES**


