1. Introduction

The Financial Accounting Standards Board (FASB) recently released an exposure draft on fair value measurements to improve the consistency, reliability, and comparability with which financial and nonfinancial assets and liabilities are reported.\footnote{It defined fair value as “the price at which an asset or liability could be exchanged in a current transaction between knowledgeable, unrelated willing parties” (FASB 2004, para. 4). Because the objective of fair value measurement is to estimate an exchange price in the absence of an actual transaction, the FASB grappled with the reliability of fair value measures, the reliability of these measures compared with the reliability of other measures based on judgements and estimates, and the causes of unreliable measures. In light of these concerns, it called for feedback on whether firms can consistently apply the fair value measurements outlined in the exposure draft. This paper examines the measurement of nonfinancial assets in imperfectly competitive markets. It also considers the effect of alternative measurements on firms’ investing and operating activities.}

Implementing fair value measurement requires a preparer of financial statements to estimate an exchange price. This estimate “is determined by reference to a current hypothetical transaction between willing parties” (FASB 2004, para. 5). In the absence of an actual transaction, the exposure draft proposes a hierarchy of information inputs that should be used to estimate fair value. The hierarchy assigns the highest priority to market inputs that reflect quoted prices in active markets and
the lowest priority to inputs based on a firm’s own estimates and assumptions using valuation techniques consistent with the market approach, income approach, and cost approach. The market approach uses prices generated by actual transactions involving identical or similar assets or liabilities; the income approach uses techniques that discount future expected cash flows or earnings; and the cost approach considers the amount required to replace an asset’s service capacity.

To examine measurement issues that arise when valuing nonfinancial assets, we consider a duopoly where two competing firms are required to value their inventory. Both firms learn the exogenous parameters of the demand function for the single product that both produce. Each firm obtains private information about the cost of manufacturing its inventory, and then both firms simultaneously and privately manufacture their inventory. They publicly report the value of their inventory using the asset valuation rule that an authoritative accounting body prescribes. After releasing their accounting reports, the firms participate in a pricing game where each firm simultaneously names a selling price and thereafter sells the commodity, at most up to its inventory holding. Consumers purchase the commodity from the firm that offers the lower price, and then, to the extent that this firm cannot meet the market demand, consumers purchase the commodity from the firm that offers the higher price. Last, the firms’ payoffs are determined. We view our model as applying to industries characterized by a few competitors that manufacture and sell homogeneous products for which the product specifications change frequently, such as in the manufacture of annual flu vaccines.

First, as a benchmark, we consider the case where both firms are required to value their inventory using historical cost — that is, inventory is valued at the cost incurred to manufacture it. We find that when firms privately observe their costs of manufacturing inventory and prepare a financial report using this valuation measure, the report does not always reveal a firm’s inventory level and, moreover, the informativeness of the report varies with the firm’s inventory level. In settings where firms study their competitor’s financial reports to learn about them, the firms are less capable of anticipating each other’s behavior. Consequently, they manufacture less inventory and in turn are less profitable than they would be in a setting where they could perfectly anticipate each other’s behavior.

Second, we consider the case where firms are required to value their inventory using the fair value rule. The firms participate in an imperfectly competitive market where they do not behave as price-takers. Accordingly, given the absence of quoted prices in an active market, we assume, consistent with the FASB’s hierarchy of information inputs, that the firms determine the value of their inventory using the income approach — that is, inventory is valued at the future cash flow that it is expected to generate. We find that when firms value their inventory using this approach, their financial statements completely reveal their inventory level. The accounting reports thus allow the firms to anticipate each other’s behavior. Therefore, firms manufacture more inventory, earn higher expected profits, and generate greater social welfare when they use fair value than when they use historical cost. In addition, reports prepared using fair value are more useful for valuing the firm than those prepared using historical cost.
Accountants have long questioned the reliability of implementing fair value measures because estimating a firm’s future cash flows is subjective (Baillie 1985; Hendriksen and Van Breda 1992). Our model addresses this concern by incorporating the following feature: at the time that the firms value their inventory and set the prices at which they are prepared to sell it, there is no exogenous source of uncertainty that can affect the firms’ future cash flows. Accordingly, our analysis focuses on the more subtle, but fundamentally important, game theoretical assumptions needed to implement the fair value rule in imperfectly competitive markets. Our study highlights that fair value measurement is an endogenous consequence of the strategic interaction between firms. Therefore, implementing the fair value rule in an imperfect and incomplete market requires preparers of financial statements to understand the multistage game between rivals in the product market so as to estimate market clearing prices. Thus, when policymakers require implementation of the fair value rule, they must assume that preparers of financial statements have this capability. This assumption is extraordinarily strong in most institutional settings.

This study explores the informativeness of alternative measurement rules when they are implemented in a strategic setting. Over the decades, the debate about the various valuation rules has primarily focused on the appropriateness of these rules while ignoring the effect of these rules on a firm’s operating and investing choices and its strategic interaction with competing firms (see, for example, Chambers’s 1966 discussion of an income model based on realizable value, Edwards and Bell’s 1961 argument favoring the use of present value and replacement cost, Ijiri’s 1971 defense of the historical cost rule, and, more recently, Lim and Sunder’s 1991 statistical analysis of valuation rules when there are price changes and these changes are measured with error). In contrast, we examine measurement rules when they are used to value transactions that are endogenous consequences of the measurements — in other words, the rivals’ actions and asset measurements are interdependent. We highlight the complexities associated with implementing measurement rules within an equilibrium setting, which is in step with Demski’s 2004 (519) call in his American Accounting Association Presidential Lecture that the FASB’s deliberation on fair value measurement requires “aggressive identification of information sources and an explicit equilibrium argument”.

Work related to our study has examined the role of information sharing in imperfectly competitive markets where firms compete in a Cournot quantity game or a Bertrand pricing game. This research typically examines the effect of duopolists’ disclosing possibly noisy information about a cost or demand parameter. For example, Hughes and Kao (1991) consider the effect on the Cournot competition between firms that disclose their research and development expenditure but may or may not disclose their actual marginal cost. Hwang and Kirby (2000) examine how a mandatory rule, which exogenously determines the noise with which firms reveal their cost parameters, affects how the firms compete in a Cournot quantity game when another firm may enter the market. Pae (2000) considers a mandatory rule requiring disclosure about market demand in a duopolistic setting where firms compete in a Cournot game. The primary difference between our model and the antecedent literature is that, in our model, firms do not reveal
information about their privately observed parameters or even their inventory choices, but rather they report the value of their inventory under a prescribed measurement rule. We find that in the historical cost regime, the informativeness of a firm’s financial report is a function of its inventory level, and its inventory level, in turn, is endogenously determined by the informativeness of its report and privately observed cost realization. Alternatively, in the fair value regime, a firm’s financial report is completely informative about its inventory level.

The observation that an asset valuation rule affects a firm’s equilibrium behavior has implications for work that assumes the law of conservation of income. This law holds that the accumulated income of a firm is invariant to changes in accounting methods, provided that these changes have no cash flow effects and income is calculated using a clean surplus rule that requires all transactions affecting owners’ equity to flow through the income statement with the exception of transactions with a firm’s owners (e.g., Ohlson 1995; Feltham and Ohlson 1995). We establish that a firm’s income and cash flows vary with the rules it uses for valuing its assets because these rules affect its equilibrium behavior.

Lastly, our paper is related to Kanodia 1980. He examines the effect of imperfect information about a firm’s production function on the stochastic behavior of its stock price, its investment decision, and a consumer’s consumption decision within a dynamic general equilibrium framework. Following this tack, several recent papers have examined how a firm’s disclosure to the capital market affects its production decisions (e.g., Kanodia and Lee 1998; Sapra 2002). A key distinction between these papers and ours is that they focus on the interaction between a single representative firm and the capital market, whereas we consider the interaction between firms in an imperfectly competitive product market and suppress the influence of the capital market on firm behavior. We view our model as capturing an important feature of the reporting environment because several studies show that firms use capacity as a coordination device and that firms choose capacity to affect the competition between them; Gilbert and Lieberman (1987), for example, find evidence of this behavior in the chemical-processing industry.

The paper proceeds as follows. Section 2 describes the model. Sections 3 and 4 characterize the equilibria when firms report their assets using historical cost and fair value, respectively. Section 5 discusses the effect of these measurements. Section 6 concludes. All proofs are contained in the appendix.

2. Model

We study an economy containing two profit-maximizing, risk-neutral firms with potentially different production technologies that supply identical products in an imperfectly competitive market. The firms participate in a game with four stages.

In the first stage, the firms observe the market demand function. Market demand as a function of price, \( p \), is given by \( D(p) = a - p \), where \( a > 0 \). Also in this stage, each firm privately observes its production technology, which determines the cost of manufacturing each unit of inventory. These unit costs, denoted \( c_i \) and \( c_j \) for firms \( i \) and \( j \), respectively, are uniformly and independently distributed on the interval \([\underline{c}, \bar{c}]\). After observing these cost realizations, the firms simulta-
neously and independently manufacture inventory, denoted $\tilde{q}_i = \bar{q}(c_i)$ and $\tilde{q}_j = \bar{q}(c_j)$ for firms $i$ and $j$, respectively.

In the second stage, firms are required to publicly disclose the value of their inventory in an accounting report. The particular measurement rule that a firm uses to prepare its accounting report is prescribed by an authoritative body. Firm $i$’s report of the value of its inventory is denoted $A_i$ and firm $j$’s report is denoted as $A_j$. The accounting report includes a balance sheet and statement of cash flows, but not an income statement because at this stage it has not sold any inventory.

In the third stage, firms simultaneously and independently name the prices at which they are prepared to sell their inventory. A firm’s pricing strategy is a function of its level of inventory, its information about its competitor’s inventory, and market demand. Since at this stage a firm’s inventory holding is fixed, it might not be capable of satisfying market demand at the price it names. Accordingly, we assume that firms face the efficient rationing rule where customers buy from the firm that offers the lower price before buying from the other firm. We let $q_i$ and $q_j$ denote the quantity of inventory that firms $i$ and $j$ sell, respectively. A firm can sell its inventory at zero marginal cost, but it cannot sell more than the inventory it holds.

In the fourth stage, the firms’ payoffs, $\Pi_i = p_i q_i - c_i \tilde{q}_i$ and $\Pi_j = p_j q_j - c_j \tilde{q}_j$, are determined and the game ends. The game is summarized in Figure 1. In the subsequent analysis, we drop the firm indices $i$ and $j$ when doing so does not cause confusion.

Rather than viewing the firms as choosing an inventory level, we could view the firms as choosing levels of capacity in a setting where the firms can produce inventories at zero marginal cost and sell at most up to their capacities. The analysis then applies to the measurement of property, plant, and equipment. When this analysis is seen as applying broadly to the measurement of a firm’s nonmonetary assets, it is likely that a firm’s financial statements will influence a rival’s formulation of its investing and operating policy.

We restrict attention to symmetric equilibria in linear pure strategies, as is standard in models of oligopolistic competition with linear demand and cost uncertainty.

**Figure 1**  Multistage game in the product market

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
<th>Stage 4</th>
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</thead>
<tbody>
<tr>
<td>(inventory choice game)</td>
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<td></td>
</tr>
<tr>
<td>Firms observe the market demand.</td>
<td>Each firm publicly discloses the value of its inventory in its accounting report, $A_i$, using the prescribed measurement rule.</td>
<td>Each firm simultaneously names a price, $p$, at which it is prepared to sell its inventory.</td>
<td>Each firm’s payoff, $\Pi$, is determined.</td>
</tr>
<tr>
<td>Each firm privately observes its cost, $c$, of manufacturing a unit of inventory, and manufactures inventory, $\tilde{q}$.</td>
<td></td>
<td>It then sells a quantity, $q_i$, of its inventory.</td>
<td></td>
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To insure equilibria in pure strategies and to rule out mixed strategy equilibria in the pricing game, we restrict the cost support so as to constrain the firms’ inventory level choices. In particular, when the firms use historical cost, we allow the cost realizations to vary in the interval \([c_H, a]\) and when they use fair value, the cost realizations vary in the interval \([c_F, a]\). The lower bound \(c_H\) or \(c_F\) is fixed so that a firm’s inventory-level choice falls in the interval \([0, a/4]\), where \(a\) equals the maximum price that consumers are willing to pay for the product (firms would not enter the market for cost realizations greater than \(a\)).

This model is related to Kreps and Scheinkman 1983. They examine sequential capacity choice and price-setting in a duopoly model. In contrast to our model, they assume that firms have the identical cost of capacity and that this cost is common knowledge. Furthermore, they assume firms’ capacity choices are publicly observable. Their game has a unique equilibrium where firms choose the Cournot level of capacity and offer the Cournot price in the pricing game. We extend their analysis by introducing cost uncertainty, and examine the consequences of firms’ reporting the value of their capacity under various measurement rules. The presence of cost uncertainty, as we shall establish, causes historical cost and fair value measurements to induce different equilibria. In Kreps and Scheinkman 1983, in contrast, if firms’ capacity costs are identical and common knowledge, then both measurements yield the Cournot outcome.

Although we should be careful not to interpret the model too literally, we suggest that our model comports with markets in which there are a few competitors that produce inventory in anticipation of a seasonal opportunity or where product specifications change frequently. Consider the market for flu vaccines in the United States. Flu vaccines are developed and manufactured in the spring and summer (based on predictions of which flu strain will thrive in the coming winter) and then distributed in the fall by Chiron Corporation and Aventis Pasteur Incorporated, the two major providers of flu vaccine in the United States (Whalen, McKay, and Lueck 2004). Vaccine that is not used during the season for which it is made goes to waste because the flu strain mutates from season to season (Cowley 2004). In such industries, information about inventory holdings and capacity would be helpful to the competing firms when setting prices.

The role of information about capacity is well illustrated in the Amino Acid Lysine Antitrust Litigation case, where Archer-Daniels-Midland (ADM) Company pleaded guilty to price fixing (Kwoka and White 2004); ADM paid a $70 million fine to the federal government, about $49 million to direct buyers of lysine, and $15 million to indirect buyers in state court cases. The United States lysine industry was an oligopoly: sales concentration was high, buyer concentration was low, the product was perfectly homogeneous, and several barriers to entry were present. The competing firms explicitly coordinated their prices by agreeing on tonnage quotas and sharing monthly sales reports; in addition, ADM had also “taken the rare step of inviting its rivals in the lysine market to an intimate tour of its capacious production facilities” so as to credibly signal its capacity (Kwoka and White 2004, 262). Although the competing firms in the lysine industry shared private information...
to facilitate collusion, White (2001, 28) notes that “the lysine industry had virtually all the characteristics of an industry in which implicit oligopolistic coordination of some kind would likely have arisen in the absence of the explicit conspiracy”. Our paper points out that accounting reports might serve to coordinate oligopolistic behavior when competing firms’ capacities are not directly observable.

3. Historical cost

In this section we characterize the equilibrium for the benchmark case when firms measure their assets using the historical cost rule. Under this rule, a firm reports its inventory at the cost to manufacture or purchase it — that is, $A = c \times \bar{q}$. Because a firm’s accounting report is the product of $c$, which the firm privately observes, and $\bar{q}$, which the firm privately chooses as a linear function of $c$, the firm’s report does not always completely reveal its inventory holding: notice that a firm that has a low unit cost and therefore chooses a high level of inventory can issue the same accounting report as a firm that has a high unit cost and therefore chooses a low level of inventory. More specifically, when the amount of inventory that a firm manufactures is declining in its cost per unit of inventory, the historical cost rule has the interesting feature that a firm’s report either completely reveals its inventory holding or reveals that its inventory is at one of two possible levels, one of which is the firm’s actual inventory holding. Formally, firm $i$’s report reduces the support of firm $j$’s beliefs about firm $i$’s inventory holding from the interval $[0, a/4]$ to either $\{\bar{q}_i\}$ or $\{\bar{q}_i^l, \bar{q}_i^h\}$, where $\{\bar{q}_i^l < \bar{q}_i^h\}$, and the situation is analogous for firm $j$’s report. We shall verify later that there is a unique equilibrium where the firms’ inventory choice strategies have the conjectured properties.

Figure 2 illustrates that when a firm privately observes its cost realization and then reports its inventory holding, its report will either completely reveal its level of inventory or reveal that its inventory is at one of two levels, one of which is the firm’s actual inventory holding.

The following two definitions are useful: First, $k$ denotes the cost realization where the accounting report attains its maximum. Second, $t$ denotes the cost realization that induces a threshold level of capacity $\bar{q}(t)$. For inventory choices less than $\bar{q}(t)$, a firm’s report completely reveals its inventory, and for inventory choices weakly greater than $\bar{q}(t)$, a firm’s report incompletely reveals its inventory. Formally, $t$ is such that when a firm’s inventory level is $\bar{q} \in [0, \bar{q}(t)]$, the report $A$ completely reveals the firm’s inventory choice $\bar{q}$, and when $\bar{q} \in [\bar{q}(t), \bar{q}(c_H)]$, the report $A$ maps (almost always) into exactly two inventory choices, $\bar{q}^l \in [\bar{q}(t), \bar{q}(k)]$ and $\bar{q}^h \in [\bar{q}(k), \bar{q}(c_H)]$, one of which is the firm’s actual inventory level $\bar{q}$.

Using backward induction, we begin by considering the pricing game played after firms manufacture and report their inventories.

Pricing game

The firms’ inventory levels are fixed when they release their accounting reports because, for example, the manufacture of inventory takes several months, as in the flu vaccine case mentioned earlier. Consequently, there are three possible single-stage pricing games, depending on the informativeness of the firms’ accounting
reports (the possibility of multistage pricing games is not analyzed): one, the firms set prices when both firms’ reports incompletely reveal their inventories; two, the firms set prices when one of the reports incompletely reveals a firm’s inventory holding and the other report completely reveals a firm’s inventory holding; and three, the firms set prices when each report completely reveals a firm’s inventory. We consider each pricing game in turn.

First, consider the pricing game played when both firms’ reports incompletely reveal their inventory holdings. In this case, firm \( i \)’s report \( A_i \) maps into exactly two inventory levels, \( q_i^l \) and \( q_i^h \), and, likewise, firm \( j \)’s report \( A_j \) maps into exactly two inventory levels, \( q_j^l \) and \( q_j^h \). Because a firm is uncertain about its competitor’s inventory, it names a price that maximizes its expected profit given its beliefs about its competitor’s inventory. Using Bayes’s rule, firm \( i \)’s posterior beliefs are \( \Pr(q_j = q_j^l | A_j) = \Pr(q_j = q_j^h | A_j) = 1/2 \), and firm \( j \)’s posterior beliefs are \( \Pr(q_i = q_i^l | A_i) = \Pr(q_i = q_i^h | A_i) = 1/2 \) (because \( c \) is uniformly distributed and \( q(c) \) is linear in \( c \)). The possible inventory levels that are consistent with the firms’ reports may be ranked, without loss of generality, as \( q_i^l \leq q_i^l < q_j^l \leq q_j^h \), where firm \( i \) is labeled as the extreme firm and firm \( j \) as the moderate firm. The unique Bayesian equilibrium in the pricing game when firms have incomplete information about each other’s inventory is characterized in the following proposition.\(^7\)

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**Figure 2** Relation between the accounting report and inventory level when a firm uses historical cost

![Figure 2](image-url)
PROPOSITION 1. Suppose neither firm’s accounting report completely reveals its inventory holding. There is a unique Bayesian equilibrium where firm i’s pricing strategy is $p_i = a - \tilde{q}_i - \tilde{q}_j$ and firm j’s pricing strategy is $p_j = a - \tilde{q}_i - \tilde{q}_j$.

Each firm sets a price as a function of its actual inventory and the highest possible inventory level consistent with its competitor’s report. This strategy ensures that a firm sells its entire inventory. The intuition for why it is not profitable for a firm to deviate from this strategy is as follows. If the firm raised its price when facing a competitor that produced the lower of the two possible inventory levels, then it would earn higher revenues. But, if it raised its price and its competitor had the higher of the two possible inventory levels, then the firm would be unable to sell its entire inventory. Because the firm’s inventory holding is less than $a/4$, when $c \in [c_H, a]$, the price elasticity of demand is such that the increase in expected revenue from the higher price is more than offset by the decrease in its expected revenue from not selling its entire inventory when its competitor has the higher inventory level. Hence, we find that a firm does not benefit from raising its price. Alternatively, a firm would not lower its price because it is already selling all its inventory.

Second, consider the pricing game played when one of the firms has a report that incompletely reveals its inventory level and the other firm has a report that completely reveals its inventory level. Without loss of generality, suppose that firm i’s report $A_i$ maps into exactly two inventory levels, $\tilde{q}_i^l$ and $\tilde{q}_i^h$, and firm j’s report $A_j$ completely reveals its inventory holding, $\tilde{q}_j$. Here, Bayes’s rule implies that firm j, on observing $A_i$, believes $Pr(\tilde{q}_i = \tilde{q}_i^l | A_i) = Pr(\tilde{q}_i = \tilde{q}_i^h | A_i) = 1/2$ (because $c_i$ is uniformly distributed and $q(c_i)$ is linear in $c_i$), and firm i, upon observing $A_j$, learns firm j’s level. The equilibrium in the pricing game is characterized in Proposition 2. The equilibrium characterization is symmetric for the converse case where $A_j$ incompletely reveals firm j’s inventory level and $A_i$ completely reveals firm i’s inventory level and is omitted.

PROPOSITION 2. Suppose that firm i’s accounting report incompletely reveals its inventory holding whereas firm j’s accounting report completely reveals its inventory holding. There is a unique Bayesian equilibrium where firm i’s pricing strategy is $p_i = a - \tilde{q}_i - \tilde{q}_j$ and firm j’s pricing strategy is $p_j = a - \tilde{q}_i^h - \tilde{q}_j$.

In this equilibrium, firm i learns firm j’s inventory level and names a price that equates consumer demand with the sum of the firms’ inventories. Firm i has no incentive to name a price that differs from $p_i = a - \tilde{q}_i - \tilde{q}_j$. To see that this is the case, suppose that firm i raises its price. Given its inventory, the price elasticity of demand is such that a higher price lowers the firm’s expected revenue because the benefit of a higher price is more than offset by the fall in demand. Conversely, firm i has no incentive to lower its price because a lower price creates demand in excess of its inventory and reduces the price it receives for the demand it can satisfy. In contrast, firm j cannot perfectly infer its competitor’s inventory level. Hence, firm j names a
price that is a function of its own inventory level and the higher of the two levels of inventory consistent with its competitor’s report. Irrespective of firm $i$’s choice, firm $j$ always sells its entire inventory. Firm $j$ names the same price as firm $i$ with probability $\Pr(\overline{q}_j = \overline{q}^h_i|A_j) = 1/2$ and names a price lower than that named by firm $i$ with probability $\Pr(\overline{q}_j = \overline{q}^l_i|A_j) = 1/2$. Firm $j$’s inability to fully anticipate firm $i$’s price reduces its expected profits. Firm $j$, nevertheless, has no incentive to offer a price that differs from $p_j = a - \overline{q}^h_i - \overline{q}_j$ for the reasons already mentioned.

Third, consider the pricing game where both firms’ reports completely reveal their inventories. The next proposition identifies equilibria for this pricing game.

**Proposition 3.** Suppose that both firms’ accounting reports completely reveal their inventory holdings. For any $\overline{q}_i$ and $\overline{q}_j$, the unique Nash equilibria in the pricing game are as follows:

(a) If the firms have inventories of $\overline{q}_i = \overline{q}_j = 0$, then neither firm names a price.

(b) If the firms have inventories of $\overline{q}_i > \overline{q}_j = 0$, then firm $i$ names a price of $p_j = a - \overline{q}^h_i$ and firm $j$ does not name a price. The situation is analogous for firm $j$ if $\overline{q}_j > \overline{q}_i = 0$.

(c) If the firms have inventories of $\overline{q}_i, \overline{q}_j > 0$, then each firm names a price of $p_i = p_j = a - (\overline{q}_i + \overline{q}_j)$.

When the firms’ reports completely reveal their inventory levels, each firm adjusts its price in response to its competitor’s actual inventory. In case (a), the reports reveal that neither firm has inventory; hence, they do not participate in the market. In case (b), only one of the firms enters the market. On observing its rival’s report, the firm that enters the market learns that it is a monopolist and sets a price that allows it to sell its entire inventory. In case (c), both firms manufacture inventory. They infer each other’s inventory from their reports and use this information to coordinate their pricing behavior in the sense that both firms name the price $a - (\overline{q}_i + \overline{q}_j)$. Because this price enables the firms to sell their entire inventory, neither firm has an incentive to lower its price so as to capture more of the market. Conversely, neither firm has any incentive to raise its price because the price elasticity of demand is such that raising price will lower revenue.

**Inventory choice game**

In the pricing game, the firms take their inventories as given. In this subsection, we consider the firms’ inventory choices. Each firm chooses its inventory level after observing its unit cost of manufacturing and anticipating its payoff in the subsequent pricing game. A firm’s payoff in the pricing game is a function of its beliefs about its competitor’s inventory choice. Its beliefs, in turn, are a function of the informativeness of its competitor’s accounting report. Recall the relation between a firm’s accounting report and its inventory level illustrated in Figure 2, and consider firm $i$’s conjecture of firm $j$’s inventory choice. Suppose $\hat{c}_j \in (t, \hat{\tau}_H)$, where $\hat{\tau}_H$ denotes the cost realization above which a firm will not manufacture any inventory when
required to report inventory at historical cost. For these cost realizations, firm \( j \)'s report is completely informative. Therefore, firm \( i \)'s pricing strategy is a function of firm \( j \)'s actual inventory level. We denote firm \( i \)'s conjecture of firm \( j \)'s inventory as a function of \( \tilde{c}_j \in [\zeta_H, t] \) as \( \hat{q}_j^i \). Alternatively, suppose that \( \tilde{c}_j \in [\zeta_H, t] \). For these cost realizations, firm \( j \)'s report is not completely informative, and firm \( i \)'s pricing strategy is a function of the highest possible level of inventory that firm \( j \) could have manufactured consistent with its report. We denote firm \( i \)'s conjecture of the highest possible level of firm \( j \)'s inventory consistent with its report as a function of \( \tilde{c}_j \in [\zeta_H, t] \) as \( \hat{q}_j^i \). Analogous definitions hold for firm \( j \)'s conjectures.

A firm chooses the amount of inventory to manufacture so as to maximize its expected profits. When it makes this choice, the firms have not yet released their accounting reports. Nevertheless, a firm anticipates learning information about its competitor’s choice before participating in the pricing game. Therefore, firm \( i \)'s objective function is (firm \( j \) has an analogous objective function):

\[
\max_{\hat{q}_j^i} \left( a - \tilde{q}_j - \mathbb{E}[\hat{q}_j^i | \zeta_H \leq \tilde{c}_j \leq t] - c_i \right) \cdot \mathbb{P}(\zeta_H \leq \tilde{c}_j \leq t) + \left( a - \tilde{q}_j - \mathbb{E}[\hat{q}_j^i | t < \tilde{c}_j < \zeta_H] - c_i \right) \cdot \mathbb{P}(t < \tilde{c}_j < \zeta_H) + \left( a - \tilde{q}_j - c_i \right) \cdot \mathbb{P}(\tilde{c}_j \leq \tilde{c}_j \leq a) \tag{1}
\]

where it is the case that:

- \( \mathbb{E}[\hat{q}_j^i | \zeta_H \leq \tilde{c}_j \leq t] \) is firm \( i \)'s expectation of the highest inventory that firm \( j \) could have manufactured consistent with firm \( j \)'s report and conditional on firm \( j \)'s observing a cost realization \( \tilde{c}_j \in [\zeta_H, t] \). Because the firms have linear strategies, it follows that

\[
\hat{q}_j^i = \begin{cases} 
\alpha_j + \beta_j \tilde{c}_j & \text{for } \zeta_H \leq \tilde{c}_j \leq k \\
\gamma_j + \delta_j \tilde{c}_j & \text{for } k < \tilde{c}_j \leq t 
\end{cases} \tag{2}
\]

When \( \zeta_H \leq \tilde{c}_j \leq k \), then \( \alpha_j \) and \( \beta_j \) are such that they map firm \( j \)'s cost realization into the highest level of inventory consistent with its report, which for these cost realizations happens to be its actual inventory level. In contrast, when \( k < \tilde{c}_j \leq t \), then \( \gamma_j \) and \( \delta_j \) are such that they map firm \( j \)'s cost realization into the highest level of inventory consistent with firm \( j \)'s report even though this firm actually manufactured the lower level of inventory consistent with its report.

- \( \mathbb{E}[\hat{q}_j^i | t < \tilde{c}_j < \zeta_H] \) is firm \( i \)'s expectation of firm \( j \)'s inventory choice conditional on firm \( j \)'s observing a cost realization \( c_j \in (t, \zeta_H) \). Because the firms have linear strategies, \( \hat{q}_j = \alpha_j + \beta_j \tilde{c}_j \) for \( t \leq \tilde{c}_j \leq \zeta_H \).
such that firm $i$ cannot perfectly infer firm $j$’s inventory from its report. The second term reflects firm $i$’s expected payoff when both firms enter the market, and firm $j$’s cost realization is such that firm $i$ learns firm $j$’s inventory from its report $A_j$. The third term is firm $i$’s expected payoff when it behaves as a monopolist in the subsequent pricing game. Observe that in each term, firm $i$ always sells its entire inventory, which is consistent with the equilibria of the pricing games in Propositions 1 to 3.

The Bayesian equilibrium for the inventory choice game is characterized in the next proposition.

**PROPOSITION 4.** When firms measure inventory using historical cost, there is a unique, symmetric Bayesian equilibrium in linear strategies in which a firm’s inventory choice is decreasing in its unit cost of manufacturing inventory. It is characterized by the following strategies:

Firm $i$’s inventory choice strategy is

$$q_i(c_i) = \begin{cases} k - c_i/2 & \text{for } c_H \leq c_i < \bar{c}_H, \\ 0 & \text{for } \bar{c}_H \leq c_i \leq a, \end{cases}$$

where $k = (18 - \sqrt{30})a/28$, $c_H = (11 - \sqrt{30})a/14$, and $\bar{c}_H = 2k$.

Firm $i$’s beliefs about firm $j$’s strategy are such that when $c_H \leq \hat{c}_j \leq t$, it expects the highest possible level of inventory consistent with its competitor’s accounting report to be

$$E[\hat{q}^h | c_H \leq \hat{c}_j \leq t] = \frac{2k^2 - 4kc_H + c_H^2 + t^2}{4(t - c_H)},$$

where $t = a/2$; and when $t < \hat{c}_j < \bar{c}_H$, it expects the level of its competitor’s inventory to be

$$E[\hat{q}_j | t < \hat{c}_j < \bar{c}_H] = k - (t + \bar{c}_H)/4.$$

Firm $i$ reports the value of its inventory at

$$A(c_i) = \begin{cases} kc_i - c_i^2/2 & \text{for } c_H \leq c_i < \bar{c}_H, \\ 0 & \text{for } \bar{c}_H \leq c_i \leq a. \end{cases}$$

Firm $j$’s strategies are analogous.
The unique equilibrium when firms report their inventory at historical cost is illustrated in Figure 3 and has the following key features. First, a firm’s inventory choice is a linear decreasing function of its cost realization. Panel A of Figure 3 illustrates the (inverse) relation between firm i’s cost realization and its inventory level choice. The inventory level varies between 0 and a/4. For cost realizations $c_i \in [\bar{c}_H, a]$, a firm does not manufacture any inventory because it believes that the price it must name to recover the cost of manufacturing its inventory is so high that it likely will be undercut by its competitor. Such a firm sets $\tilde{q}_i = 0$ and Forgoes entering the market. In contrast, for the lowest possible cost realization $c_i = \zeta_H$, the firm manufactures inventory of $\tilde{q}_i = a/4$.

Second, a firm’s report of its inventory is strictly concave in the quantity of inventory that it manufactures. Panel B of Figure 3 represents this functional relation. When a firm manufactures inventory of $\tilde{q}_h < k - t/2$, its report completely reveals its inventory holding, and when it manufactures inventory of $\tilde{q}_i \approx k - t/2$, its report reveals that its inventory is one of two values, one of which corresponds to its actual inventory level. Therefore, historical cost generally does not completely reveal a firm’s inventory holding despite the fact that the relation between the per unit manufacturing cost and the inventory choice is so simple. Hence, although it is widely recognized that financial statements provide information to competitors about firms’ production technologies (Hwang and Kirby 2000; Sinha and Watts 2001), we observe that, even in this simple setting, firms might benefit from gathering information from other sources, such as visits to its competitor’s stores and warehouses, a possibility we suppress.

Third, each firm names a price as a function of its own inventory level and its beliefs about its competitor’s inventory level. Consider firm j’s perspective after observing firm i’s report. Panel C of Figure 3 graphs the (inverse) correspondence between firm i’s unit cost of inventory $c_i$ on the vertical axis and the highest level of inventory consistent with firm i’s report, denoted as $\hat{q}_i$ on the horizontal axis.

When firm i’s cost realization is such that $c_i \in (t, \bar{c}_H]$, then firm i’s accounting report completely reveals its inventory. In this case, when firm j sets its price, the quantity of inventory that it attributes to firm i as a function of that firm’s per unit cost is given by $\hat{q}_i = k - \bar{c}_i/2$. Here, firm j names a price that is decreasing in both its cost and the cost of firm i. When firm i’s cost realization is such that $c_i \in [\zeta_H, t]$, then its report is consistent with it having one of two possible inventory levels and firm j responds by offering a price that is a function of its inventory and the highest inventory level consistent with firm i’s report. In this case, when firm j sets its price, the quantity of inventory that it attributes to firm i as a function of firm i’s per unit cost is given by

$$
\hat{q}_i^h = \begin{cases} 
  k - \bar{c}_i/2 & \text{for } \zeta_H \leq \bar{c}_i \leq k \\
  \bar{c}_i/2 & \text{for } k < \bar{c}_i \leq t 
\end{cases}
$$
Figure 3  Relation between a firm’s inventory and its cost realization, accounting report, pricing function, and the informativeness of its report under the historical cost rule

Panel A: Relation between firm $i$’s cost realization and its inventory

Panel B: Relation between firm $i$’s report and its inventory

(The figure is continued on the next page.)
This function is the same as that specified in (2) except now the equilibrium values of the parameters have been determined. For the cost realizations $c_i \in [c_{tH}, k]$, firm $i$ manufactures the largest inventory level consistent with its report, and firm $j$ chooses a price consistent with firm $i$'s actual inventory choice. Here, the price that firm $j$ names is increasing in its competitor’s cost of inventory. In contrast, for the cost realizations $c_i \in (k, t)$, firm $i$'s report is consistent both with its actual inventory choice and a higher level. In equilibrium, it is this higher level, and not the actual inventory choice, that firm $j$ uses in its pricing function. Accordingly, firm $j$ lists a price that is decreasing in its competitor’s cost of inventory. In this regard, the historical cost differs from fair value because, as we show later, the latter rule
always reveals the firms’ inventory holding and allows them to name prices that increase in their cost realizations.

Fourth, the precision with which a firm’s report conveys its inventory is discontinuous and nonmonotonic in its inventory choice, as illustrated in panel D of Figure 3. Holding market size a constant, we find that for inventory levels below $k - t/2$, the firm’s report completely reveals its inventory level. When the firm’s inventory equals $k - t/2$, the report is least informative about its inventory. As the firm’s inventory increases above $k - t/2$, the report’s informativeness increases until $q_i = k/2$, where it is completely informative, and thereafter decreases in inventory. Thus, a noteworthy feature of using historical cost is that the informativeness of a firm’s report is an endogenous consequence of its inventory choice, which, in turn, is a function of the report’s informativeness. We can also show that the expected variance of the information that a firm’s report provides is increasing in the market size parameter $a$ — even when there is no noise in demand.

A report prepared using historical cost does not always completely reveal a firm’s inventory holding. Consequently, a firm obtains less benefit from committing to a course of action through its investment in inventory or capacity than it does in a setting where its investment in inventory or capacity is observable. Accordingly, this paper contributes to work that examines the value of commitment in oligopolistic games (e.g., Bagwell 1995; Maggi 1999); it also contributes to recent work that considers how a firm’s investment choice is affected by its financial disclosures to the capital market (e.g., Kanodia and Lee 1998; Sapra 2002).

Generally accepted accounting principles require inventory to be valued at the lower of cost or market (that is, the LCM principle). In the absence of information shocks after the firms have privately observed their cost realizations, the fair value, or expected revenues from disposing of the inventory, must exceed the historical cost of the inventory for the firms to be profit maximizing. Hence, the reporting of inventory under the historical cost rule in this analysis satisfies the LCM principle.

4. Fair value

In this section, we consider a setting where firms use fair value to measure their assets. The firms participate in an imperfectly competitive market where they do not behave as price-takers. Accordingly, given the absence of quoted prices for the inventory, we assume, consistent with FASB’s hierarchy of information inputs outlined in its exposure draft on fair value measurements, that the firms determine the value of their inventory using the income approach. This approach values inventory at the future cash flow that it is expected to generate; formally, firms report $A = E[p \times q_i | c]$. Alternatively, a firm might consider using the cost approach, which emphasizes the current replacement cost of the inventory. Because each firm uses its proprietary technology to synergistically combine several inputs to produce the finished good, the cost approach is not as useful as the income approach for estimating fair value in the setting considered here (Zyla 2003).

We begin by considering the pricing games that the firms play after they release their accounting reports. We conjecture that when a firm’s report is prepared using fair value, the report completely reveals the firm’s inventory holding.
After establishing the equilibria to the pricing games, we characterize the equilibrium to the inventory choice game. We show that this equilibrium is unique, and we confirm our conjecture that the reports prepared using fair value fully reveal the firms’ inventories.

**Pricing game**

A firm names its selling price after observing its competitor’s accounting report. Since we conjecture that a report prepared using fair value completely reveals a firm’s inventory level, the Nash equilibrium to the pricing game is the same as that characterized in Proposition 3: that is, either both firms remain out of the market; or one of the firms, say, firm $i$, enters the market and names a price $p_i = a - \bar{q}_i$ while firm $j$ does not enter; or both firms enter the market and name a price $p_i = p_j = a - \bar{q}_i - \bar{q}_j$ that allows them to sell all their inventory.

**Inventory choice game**

We now examine a firm’s inventory choice. A firm chooses its inventory after learning its per unit manufacturing cost and anticipating its payoff in the subsequent pricing game. We let $c_F$ denote the cost realization above which a firm will not manufacture any inventory when required to use fair value. Proposition 3 shows that a firm’s pricing behavior depends on whether it is a monopolist or duopolist, which it learns after observing its rival’s report. In this light, firm $i$ chooses its inventory level to maximize its expected payoff, given by the objective function (firm $j$ has an analogous objective function)

$$
\max_{\bar{q}_i} (a - \bar{q}_i - \mathbb{E}[\hat{q}_j | c_F \leq \check{c}_j < c_F - c_i]) \bar{q}_i \times \Pr(c_F \leq \check{c}_j < c_F)
$$

$$+ \quad (a - \bar{q}_i - c_i) \bar{q}_i \times \Pr(c_F \leq \check{c}_j \leq a) (3),$$

where $\mathbb{E}[\hat{q}_j | c_F \leq \check{c}_j < c_F]$ is firm $i$’s expectation of firm $j$’s inventory, conditional on firm $j$’s observing a cost realization $\check{c}_j \in [c_F, \tau_F]$. Because the firms have linear strategies, $\hat{q}_j = a_f + \beta \check{c}_j$ for $c_F \leq \check{c}_j < c_F$. Both terms of firm $i$’s objective function reflect the fact that when it enters the market, it sells its entire inventory.

The unique Nash equilibrium to the inventory choice game is characterized next. In this equilibrium, a firm’s accounting report completely reveals its inventory choice.

**Proposition 5.** When firms measure inventory using fair value, there is a unique symmetric Nash equilibrium in linear strategies. It is characterized by the following strategies:

Firm $i$’s inventory choice strategy is

$$
\bar{q}_i(c_i) = \begin{cases} 
(5 - \sqrt{2})a/8 - c_i/2 & \text{for } c_F \leq c_i < \check{c}_F, \\
0 & \text{for } \check{c}_F \leq c_i \leq a.
\end{cases}
$$
where $c_F = (3 - \sqrt{2})a/4$ and $\bar{c}_F = (5 - \sqrt{2})a/4$.

**Firm i reports the value of its inventory at**

$$A(c_i) = \begin{cases} (27 - 10\sqrt{2})a^2 / 64 - c_i^2 / 4 & \text{for } c_F \leq c_i < \bar{c}_F, \\ 0 & \text{for } \bar{c}_F \leq c_i \leq a \end{cases}$$

**Firm j uses analogous strategies.**

The inventory that a firm chooses to manufacture is strictly decreasing in its privately observed cost realization (for all $c < c_F$). The intuition is that as a firm’s cost realization increases, the price that it must name to profitably sell its inventory increases, which, in turn, raises the probability that the other firm will undercut its price. If the firm’s price is undercut, it might not sell all its inventory. This possibility induces the firm to manufacture less inventory. Indeed, when a firm’s cost realization is at least $\bar{c}_F$, the price that it must name to be profitable is sufficiently likely to be undercut that it chooses not to manufacture any inventory. In this case, the firm’s report equals zero.

Rather than expressing the reporting function in terms of the firm’s cost realization, we could express it in terms of the firm’s inventory choice. In this case, the accounting report, which reflects the firm’s expected revenue, is strictly increasing in the firm’s inventory level over the domain of inventory choices $[0, \bar{c}(c_F)]$; a firm’s expected revenue must be increasing in its inventory in the pricing game when its costs are sunk because otherwise the firm would not be profit maximizing. Because the firms correctly conjecture the relation between inventory and revenue in equilibrium, once a firm reports its expected revenue, the other firm can perfectly infer its inventory holding. This feature of the fair value measurement allows firms to perfectly anticipate the price that their rival will name.

The analysis assumes that the firms perfectly implement the fair value rule. In an environment where the rule is imperfectly implemented because, for example, firm managers are not fully rational, or the managers opportunistically manipulate the accounting reports, or their objective functions are incorrectly specified, then the fair value rule might not have the feature that a firm’s accounting report reveals its inventory level.

5. Discussion

Because the firms’ accounting reports are released after they manufacture their inventory but before they sell it, this paper examines the role of an accounting report as a leading indicator of a firm’s expected performance. The accounting report includes a balance sheet and statement of cash flows. A balance sheet that reports the fair value of a firm’s inventory allows competing firms, investors, and other users to infer a firm’s unit cost and level of inventory, and therefore the cost of the firm’s inventory. Also, with this information and the equilibrium pricing
strategies in mind, users can infer the price that a firm intends to name. Before the pricing game, users can use a firm’s balance sheet to infer the firm’s revenue, $p \times \bar{q}$, and its value $(p - c) \times \bar{q}$. In contrast, a balance sheet prepared using historical cost does not always allow users of the report, such as investors or the firm’s competitors, to infer its inventory level and consequently the revenue that it will generate. Therefore, such an accounting report provides insufficient information to determine the firm’s value. Indeed, under the historical cost rule, investors can only determine a firm’s value after it has participated in the pricing game and reported its results. The accounting report might also contain a statement of cash flows; it, however, does not provide any additional information over and above the balance sheet under either valuation rule. Last, the accounting report does not contain an income statement. An income statement is only meaningful after the firms have operated, which occurs in the pricing game. Nevertheless, our insights will hold in a multiperiod setting where firms also present an income statement, provided that the consequences of management decisions extend over more than one accounting period so that the balance sheet continues to contain information not in the income statement.

The alternative asset measurements influence a firm’s ability to anticipate the competitor’s price, which affects the firm’s profitability. A firm’s profitability, in turn, affects its willingness to manufacture inventory so as to meet consumer demand. The next proposition analyzes the effect of these measurements on firm profitability, consumer surplus, and social welfare. To ensure comparability, the common cost support is given by $[\zeta, a]$, where $\zeta = \max(\zeta_H, \zeta_F) = \zeta_F$.

**Proposition 6.** Expected firm profits are higher, expected consumer surplus is lower, and, in aggregate, expected social welfare is higher when firms use fair value than when they use historical cost.

Firms can better coordinate their prices when their accounting reports are prepared using fair value rather than historical cost. Accordingly, when firms use fair value, they obtain higher prices, manufacture more inventory, and obtain higher expected profits. Higher expected prices lower expected consumer surplus. Nevertheless, in aggregate, the higher expected profits more than offset the lower expected consumer surplus and higher expected social welfare results.

Proposition 6 shows that firms can be better off when they communicate their inventory levels. Accordingly, when their accounting reports do not completely reveal their inventories, firms might voluntarily communicate this information. This communication, if credible, would allow them to compete less aggressively and thereby capture a larger proportion of the social surplus. Unless this disclosure is audited, however, it is not credible because each firm has an incentive to falsely claim that it has manufactured small amounts of inventory. This claim encourages its competitor to name a higher price. The firm then can easily undercut its competitor’s price and profitably capture the market. Of course, its competitor rationally anticipates this dissembling, and consequently, it ignores the firm’s disclosure (see Ziv 1993). This argument suggests that, in the absence of an audited report, a firm cannot credibly reveal its information voluntarily in this game.\(^9\) Because firms
cannot credibly disclose their private information voluntarily, this analysis high-
lights that the asset measurement rules that policy-makers prescribe have different 
real economic effects.

6. Conclusion

This paper examines the measurement of nonfinancial assets in imperfectly com-
petitive markets. We analyze a model where firms make sequential manufactur-
ing and pricing choices in a duopoly. After manufacturing inventory but before naming 
prices, firms report their inventory at either historical cost or fair value. In the 
absence of cost uncertainty, a report prepared using either measurement com-
pletely reveals a firm’s inventory level. In contrast, the presence of cost uncertainty 
reduces the informativeness of a report prepared using historical cost whereas one 
prepared using fair value continues to completely reveal a firm’s inventory holding. 

Accountants have long been critical of fair value measurements because esti-
mates of future cash flows are subjective. By suppressing uncertainty attributable 
to market demand, we construct a model with the feature that when firms value 
their inventory, there is no exogenous source of uncertainty that might confound 
estimating the cash flows that the firms generate. Despite eliminating this source of 
uncertainty, we find that the strategic interaction between firms in an imperfectly 
competitive market generates an endogenous source of uncertainty. To measure the 
fair value of assets in the presence of this type of uncertainty, preparers of financial 
statements must have an intimate understanding of the multiperiod game between 
the firms so that they can determine market clearing — or equilibrium — prices. 
This assumption, however, is typically difficult to satisfy in a complex institutional 
setting.

We highlight this implementation issue while assuming that the rival firms can 
unambiguously compute and credibly disclose their asset values in equilibrium. 
We deliberately suppress the auditability concern commonly associated with fair 
value measurements (see American Institute of Certified Public Accountants 
2003). Nevertheless, it is readily apparent from observing the vital role of the com-
mon knowledge assumption in our equilibrium analysis that there are additional 
complexities associated with auditing fair value measurements. For example, how 
might the multistage game between rivals become common knowledge among the 
independent auditors so that they can determine the equilibrium, thereby allowing 
them to appropriately opine on their clients’ asset measurements? In light of the 
conceptual and practical difficulties involved in implementing the fair value rule 
when firms behave strategically, it is not surprising that the FASB’s Emerging 
Issues Task Force eliminated a four-year-old ruling that allowed energy-trading 
companies to use fair value accounting on a wide range of energy contracts and 
instead required firms to value these contracts at historical cost (Weil 2002).
Appendix

Proof of Proposition 1

The proof proceeds by showing the (weak) optimality of the equilibrium pricing strategies, given the four levels of inventory that the firms might have manufactured: firm $i$ manufactured inventory $\tilde{q}_i^l$ or $\tilde{q}_i^h$ and firm $j$ manufactured inventory $\tilde{q}_j^l$ or $\tilde{q}_j^h$. We show the optimality of the pricing strategy for the case when firm $i$ manufactured inventory of $\tilde{q}_i^l$. The proof of the remaining cases follows similarly and is omitted.

Consider firm $i$'s pricing strategy when it manufactured inventory $\tilde{q}_i = \tilde{q}_i^l$. In equilibrium, firm $i$ names a price of $p_i = a - \tilde{q}_i^l - \tilde{q}_j^h$ and firm $j$ names a price of $p_j = a - \tilde{q}_j^h - \tilde{q}_j^l$, where $\tilde{q}_j \in \{q_j^l, q_j^h\}$. Since firm $j$ is the moderate firm (that is, $\tilde{q}_j^h < \tilde{q}_j^h$ almost always), firm $i$ is undercut by firm $j$. Under the efficient rationing rule, firm $i$ faces a residual demand of at least $\tilde{q}_i^l$. Hence, firm $i$ obtains profits of

$$II_i = \Pr(\tilde{q}_j = q_j^l | A_j)p_i q_i^l \Pr(\tilde{q}_j = \tilde{q}_j^l) + \Pr(\tilde{q}_j = q_j^h | A_j)p_j q_i^l = p_i q_i^l.$$  

Now consider whether there are strictly profitable deviations for firm $i$ from the equilibrium pricing strategy. If firm $i$ raises its price above $p_i = a - \tilde{q}_i^l - \tilde{q}_j^h$ to, say, $p_i' = p_i + \epsilon$, where $\epsilon > 0$, then its expected profits are given by

$$II_i' = \Pr(\tilde{q}_j = q_j^l | A_j)p_i' \min(q_i^l, q_i^l + q_j^l - \epsilon - q_j^l) \Pr(\tilde{q}_j = q_j^h | A_j)p_j q_i^l = p_i q_i^l + \epsilon(3q_i^l + q_j^h - a - \epsilon)/2.$$

We observe that $II_i \approx II_i'$ if $3q_i^l + q_j^h - a < 0$. Because $q_i^l, q_j^h \leq a/4$ and $q_i^l < q_j^h$, it follows that $3q_i^l + q_j^h - a < 0$. Hence, firm $i$ has no incentive to raise its price. Firm $i$ also has no incentive to lower its price because this rations the market and lowers its revenue. Finally, it can be shown that the equilibrium is unique.

Proof of Proposition 2

One of the firm’s reports incompletely reveals its inventory level whereas the other firm’s report completely reveals it. Without loss of generality, suppose that firm $i$’s report $A_i$ is consistent with its having manufactured inventory of either $q_i^l$ or $q_i^h$ and firm $j$’s report $A_j$ completely reveals its inventory level $\tilde{q}_j$. The proof proceeds by showing the (weak) optimality of the equilibrium pricing strategies for each firm.

First, consider firm $i$’s pricing strategy when it manufactured inventory of $\tilde{q}_i = q_i^l$. Firm $i$ names a price of $p_i = a - q_i^l - \tilde{q}_j$ and firm $j$ names a price of $p_j = a - q_j^h - \tilde{q}_j^l$. Since $q_i^l < q_j^h$, firm $i$ is always undercut by firm $j$, and it obtains profits of $II_i = (a - q_i^l - \tilde{q}_j)q_i^l$. If it deviates and names a higher price, say, $p_i' = p_i + \epsilon$, where $\epsilon > 0$, then it earns expected profits of

$$II_i' = (p_i + \epsilon)(q_i^l - \epsilon) = (a - q_i^l - \tilde{q}_j)q_i^l + \epsilon(2q_i^l + \tilde{q}_j - a - \epsilon).$$
Note that $I_i \geq I_i'$ if $2\bar{q}_i^l + \bar{q}_j \leq a$. Since $2\bar{q}_i^l + \bar{q}_j < 2\bar{q}_i^h + \bar{q}_j \leq a$, firm $i$ has no incentive to raise its price. Also, firm $i$ has no incentive to lower its price because it would ration the market without generating larger revenue.

Consider firm $i$’s pricing strategy when it manufactured inventory of $\bar{q}_i = \bar{q}_i^h$. In equilibrium, firm $i$ names a price of $p_i = a - \bar{q}_i^h - \bar{q}_j$ and firm $j$ names a price of $p_j = a - \bar{q}_i^h - \bar{q}_j$. The firms sell all of their inventory, and firm $i$ obtains profits of $\Pi_i = p_i\bar{q}_i^h$. If firm $i$ deviates and raises its price to $p_i' = p_i + \epsilon$, where $\epsilon > 0$, then its expected profits are

$$\Pi_i' = (p_i + \epsilon)(\bar{q}_i^h - \epsilon) = p_i\bar{q}_i^h + \epsilon(2\bar{q}_i^h + \bar{q}_j - a - \epsilon).$$

Observe $\Pi_i \geq \Pi_i'$ if $2\bar{q}_i^h + \bar{q}_j \leq a$. Since $2\bar{q}_i^h + \bar{q}_j < 3\bar{q}_i^h + \bar{q}_j \leq a$, firm $i$ has no incentive to raise its price. Likewise, firm $i$ has no incentive to lower its price because this defection rations the market and does not raise revenue.

Consider firm $j$’s pricing strategy. When firm $j$ names a price of $p_j = a - \bar{q}_i^h - \bar{q}_j$, its expected profits are $\Pi_j = p_j\bar{q}_j^h$. Suppose that firm $j$ deviates and raises its price to $p_j' = p_j + \epsilon$, where $\epsilon > 0$. Then its expected payoffs are

$$\Pi_j' = \Pr(\bar{q}_i = \bar{q}_i^h|A_j)(p_j + \epsilon)\bar{q}_j + \Pr(\bar{q}_i = \bar{q}_i^h|A_j)(p_j + \epsilon)(\bar{q}_j - \epsilon)
\quad = \bar{q}_j p_j + \epsilon(3\bar{q}_j + \bar{q}_i^h - a - \epsilon)/2.$$  

Note that $\Pi_i \geq \Pi_j'$ if $3\bar{q}_j + \bar{q}_i^h < a$. Because $\bar{q}_i^l, \bar{q}_j \leq a/4$, it follows that $3\bar{q}_j + \bar{q}_i^h < a$ and therefore firm $j$ has no incentive to deviate. Clearly firm $j$ has no incentive to lower its price. Finally, it can be shown that the equilibrium is unique.

**Proof of Proposition 3**

The argument to rule out equilibria in mixed strategies follows directly from Kreps and Scheinkman 1983 and is omitted. We next consider the three cases in the Proposition. Case (a) is trivial. In case (b), firm $i$’s objective function is

$$\max_{p_i} D(p_i) p_i \quad \text{subject to} \quad D(p_i) \leq \bar{q}_i.$$  

Using the Kuhn-Tucker conditions, we find that firm $i$’s pricing strategy in the monopoly pricing game is given by $p_i = a - \bar{q}_i^l$ for $\bar{q}_i \leq a/2$. Then, given that $D(p_i) = a - p$ and $\bar{q}_j \leq a/2$, revenue for firm $i$ is $(a - \bar{q}_j)p_i$ in case (b). In case (c), the proof follows immediately from Proposition 1 in Kreps and Scheinkman 1983 and is omitted here.
**Proof of Proposition 4**

Firm $i$'s inventory choice problem in (1) may be rewritten as

$$
\max_{\tilde{q}_i} (a - \tilde{q}_i - c_i) \tilde{q}_i - E[\tilde{q}_j | \tilde{c}_j \leq \tilde{t}] \tilde{q}_i \Pr(\tilde{c}_H \leq \tilde{c}_j \leq \tilde{t}) \\
- E[\tilde{q}_j | \tilde{t} < \tilde{c}_j < \tilde{c}_H] \tilde{q}_i \Pr(\tilde{t} < \tilde{c}_j < \tilde{c}_H).
$$

Differentiating with respect to $\tilde{q}_i$, using the first-order condition, substituting in $\tilde{q}_j^h$ and $\tilde{q}_j$, and solving for $\tilde{q}_i$ yields firm $i$'s optimal inventory choice $\tilde{q}_i$. The uniqueness of this choice follows because the second-order condition is satisfied here.

For firm $i$'s conjecture about the highest inventory level that firm $j$ could hold, $\tilde{q}_j^h$, to be consistent with firm $j$'s actual inventory holding, $\tilde{q}_j$, it must be true that when firm $j$'s report attains its maximum, firm $i$ can perfectly infer firm $j$'s inventory level. Hence, at cost realization $k$ it must be the case that $\alpha_j + \beta_j k = \gamma_j + \delta_j k$. Rearranging and substituting $\tilde{\delta}_j = (\alpha_j - \gamma_j)/k + \beta_j$ into firm $i$'s optimal inventory choice $\tilde{q}_i$ yields

$$
\tilde{q}_i = \left[\frac{a}{2} - \frac{\alpha_i (c_i - \tilde{c}_H + \tilde{c}_j - t) + \gamma_j (t - k)}{2(a - \tilde{c}_H)} \right] - \frac{c_i}{2}.
$$

Firm $j$'s inventory choice is determined in an analogous fashion. Observe that $\beta_i = \beta_j = -1/2$. Thus, we can write firm $i$'s inventory choice strategy as $\tilde{q}_i(c_i) = \alpha_i - c_i/2$. Hence, $c_i = \tilde{q}_i^{-1} = 2\alpha_i - 2\tilde{q}_i$. Substituting $c_i$ into $A_j$ yields $A_j = c_i \times \tilde{q}_j = (2\alpha_i - 2\tilde{q}_i) \times \tilde{q}_j$. The report, $A_j$, attains its maximum at $\tilde{q}_j^h = \alpha_i/2$. Therefore, $k_i = \alpha_i$. Since $\alpha_i$ is independent of $c_i$, $k = k_i = k_j = \alpha_i = \alpha_j$. Substituting $k = \alpha_i$ and $\beta_i = -1/2$ into $\delta_i = (\alpha_i - \gamma_i)/k + \beta_i$, yields $\delta_i = 1/2 - \gamma_i/k$. Now substitute $\alpha_j = k$ and $\delta_i = 1/2 - \gamma_i/k$ into the intercept of firm $i$'s optimal inventory choice (that is, the bracketed terms in the above expression for $\tilde{q}_j$). Set this intercept equal to $k$ and solve to obtain $\gamma_i$. Substitute this expression for $\gamma_i$ into $\delta_i = 1/2 - \gamma_i/k$. By definition, $\tilde{c}_H$ is such that $\tilde{q}_i(\tilde{c}_H) = 0$; hence, $\tilde{q}_i(\tilde{c}_H) = \alpha_i - \tilde{c}_H/2 = 0$. Because $\alpha_i = k$, note that $\tilde{c}_H = 2k$. Substituting $\tilde{c}_H = 2k$ into the expressions for $\gamma_i$ and $\delta_i$ gives

$$
\gamma_i = k + k \times \frac{(2k - \tilde{c}_H)^2 - 4(a - \tilde{c}_H)(a - 2k)}{2(k - t)^2}
$$

and

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\[ \delta_i = -\frac{1}{2} \frac{(2k - \xi_H)^2 - 4(a - \xi_H)(a - 2k)}{2(k - t)^2}. \]

Furthermore, for firm \( j \)'s report to reveal that it has manufactured inventory of either \( \bar{q}_j^1 \) or \( \bar{q}_j^2 \) (but not completely reveal its inventory choice when \( \bar{q}(c_j) = \bar{q}(t) \)), it is necessary that \( \xi_H(k - \xi_H (k - t)) = t(k - t/2) \). Solving for \( t \) yields \( t = 2k - \xi_H \).

Moreover, in equilibrium, the effect on firm \( i \)'s pricing strategy of firm \( j \)'s inventory choice when it observes either \( \bar{q}_j^1 \) or \( \bar{q}_j^2 \) must be such that \( \frac{\partial R_i}{\partial \xi_j} = 0 \). Substituting the equilibrium conditions for \( \bar{q}_j^1, \bar{q}_j^2, \bar{q}_j^3, \bar{q}_j^4, \) and \( c_j \) into \( \frac{\partial R_i}{\partial \xi_j} \) and recognizing that \( k \), we solve for \( k \) to obtain

\[ k = \frac{4}{3} \xi_H - \frac{2}{3} a + \frac{1}{6} \sqrt{(46a^2 - 88a\xi_H + 40a^2)}. \]

Since \( k = \alpha_i \), firm \( i \)'s inventory choice strategy can be expressed as

\[ \bar{q}(c_i) = \alpha_i + \beta_i \times c_i = \frac{4}{3} \xi_H - \frac{2}{3} a + \frac{1}{6} \sqrt{(46a^2 - 88a\xi_H + 40a^2)} - \frac{1}{2}c_i. \]

A sufficient condition for the equilibria characterized in the pricing game to be unique is \( \bar{q}_i^1, \bar{q}_i^2 \leq a/4 \). For \( \bar{q}_i^1, \bar{q}_i^2 \leq a/4 \), we require that \( \xi_H \geq (11 - \sqrt{30})a/14 \).

Hence, we observe \( k = (18 - \sqrt{30})a/28, \xi_H = (18 - \sqrt{30})a/14 \), and \( t = a/2 \).

Furthermore, \( \gamma_i = 0 \) and \( \delta_i = 1/2 \). Finally, using historical cost, \( A_i = c \times \bar{q}_i^1 \); hence, we substitute in \( \bar{q}_i = k - c_j/2 \) to obtain the firm’s report.

**Proof of Proposition 5**

Consider firm \( i \); analogous arguments apply for firm \( j \). Firm \( i \)'s problem of choosing its inventory level in (3) can be rewritten as

\[ \max_{\bar{q}_i} (a - \bar{q}_i - c_i) \bar{q}_i - \mathbb{E}[\bar{q}_j^1|\xi_F] \xi_F \preceq \tilde{c}_j < \tilde{c}_F] \mathbb{I}_i \Pr(\xi_F \preceq \tilde{c}_j < \tilde{c}_F). \]

Differentiating with respect to \( \bar{q}_i \), using the first-order condition, and solving for \( \bar{q}_i \) yields firm \( i \)'s optimal inventory choice \( \bar{q}_i \). Now, substituting the expression for \( \mathbb{E}[\bar{q}_j^1|\xi_F] \xi_F \preceq \tilde{c}_j < \tilde{c}_F] \) into \( \bar{q}_i \) and solving simultaneously for \( \alpha_i, \alpha_j, \beta_i, \) and \( \beta_j \) gives

\[ \alpha_i = \alpha_j = \frac{\tau_F^2 - \xi_F^2 + 4(a - \xi_F)}{4[\tau_F^2 - \xi_F^2 + 2(a - \xi_F)]}. \]
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and \( \beta_i = \beta_j = -1/2 \). We observe that \( \tilde{q}(c_i) \) is linear in \( c_i \) as conjectured. Furthermore, the unique optimality of this inventory choice follows from the second-order condition, which is satisfied here.

In equilibrium, \( \tilde{q}_i \approx 0 \) if and only if \( c_i \leq \tilde{\epsilon}_F \). The threshold for \( c_i \) above which the firm will not enter the market is found by solving for \( \tilde{\epsilon}_F \) in the expression \( \tilde{q}(\tilde{\epsilon}_F) = 0 \). We rule out the root implying that \( \tilde{\epsilon}_F \leq c_F \) in the quadratic equation to isolate the unique value \( \tilde{\epsilon}_F = (\sqrt{2} - 1)(2a - c_F + \sqrt{2} c_F) \). Substituting the expression for \( \tilde{\epsilon}_F \) into the expression for \( \tilde{q}(c_i) \) derived above yields

\[
\tilde{q}(c_i) = \frac{1}{2} (\sqrt{2} - 1)(2a - c_F + \sqrt{2} c_F) - \frac{1}{2} c_i \quad \text{for} \quad c_F < c_i < \tilde{\epsilon}_F.
\]

A sufficient condition for the equilibria characterized in the pricing game to be unique is \( \tilde{q}_i^h, \tilde{q}_j^h \leq a/4 \). For \( \tilde{q}_i^h, \tilde{q}_j^h \leq a/4 \), we require that \( c_F \geq (3 - \sqrt{2})a/4 \). Given that \( c_F = (3 - \sqrt{2})a/4 \), we find that \( \tilde{\epsilon}_F = (5 - \sqrt{2})a/4 \). This observation establishes \( \tilde{q}(c_i) \).

It remains to determine the firm’s report as a function of \( c_i \) and show that it is invertible. Since the firm sells all its inventory, \( q_i = \tilde{q}_j \). After substituting for \( \tilde{q}_i, \tilde{q}_j \), and \( \Pr(\tilde{\epsilon}_F \leq \tilde{\epsilon}_j < \tilde{\epsilon}_F) \) into the expression

\[
A_j = (a - \tilde{q}_j) \tilde{q}_j - \mathbb{E}[\tilde{q}_j | \tilde{\epsilon}_F \leq \tilde{\epsilon}_j < \tilde{\epsilon}_F] \tilde{q}_j \Pr(\tilde{\epsilon}_F \leq \tilde{\epsilon}_j < \tilde{\epsilon}_F)
\]

and simplifying, we obtain the equilibrium expression for \( A_j \) when \( c_F < c_i < \tilde{\epsilon}_F \). It is immediate that \( A_j = 0 \) for \( \tilde{\epsilon}_F \leq c_i \leq a \). Because \( \partial A_j / \partial c_i = -c_i/2 < 0 \) for all \( c_i \leq \tilde{\epsilon}_F \), \( A_j \) is invertible for all \( c_i \in [c_F, \tilde{\epsilon}_F] \). Given the firm’s equilibrium inventory choice strategy \( \tilde{q}(c_i) \), \( A_j \) completely reveals \( \tilde{q}_i \). Finally, it can be established that the symmetric Nash equilibrium in linear strategies is unique. \( \blacksquare \)

**Proof of Proposition 6**

Because the common cost support is given by \( [\xi, a] \), where \( \xi = \max(\xi_h, \xi_F) = \xi_F \), we first determine the equilibrium when firms are required to report their inventory at historical cost when \( c_i, c_j \in [\xi_F, a] \). We can now determine the expected firm profits, expected consumer surplus, and expected social welfare for each of the asset measurements at the start of the game — that is, before the firms observe their cost realizations and choose their inventories. After long but straightforward calculations, we find that expected firm profits are higher and expected consumer surplus is lower when firms report inventory using fair value than historical cost. Finally, defining expected social welfare as the sum of expected firm profits and expected consumer surplus, we find expected social welfare is higher when firms report inventory using fair value than historical cost. \( \blacksquare \)
Endnotes


2. The game we examine differs from a Cournot or Bertrand game. In a Cournot game, firms choose quantity and then a Walrasian auctioneer sets a price that clears the market. Thereafter, the firms, which are not inventory constrained, supply the appropriate quantity to the market. A Bertrand game is similar except that firms choose price. The Edgeworth-Bertrand game we analyze has a inventory choice stage followed by a inventory-constrained pricing game.

3. More generally, the qualitative insights we offer continue to hold when each firm has nonuniform beliefs about its competitor’s cost per unit of inventory and when the firms’ costs are (imperfectly) correlated because each firm continues to have some private information about its own costs.

4. We do not consider mixed strategies, which would blunt our focus on the informativeness of the valuation rules because mixed strategies serve to hide the firms’ decisions. In addition, an equilibrium where firms randomize over prices is difficult to rationalize as a description of firm behavior (Davidson and Deneckere 1986; Hvid 1990; Tirole 1993): such an equilibrium has the unappealing property that consumers react more quickly than a firm does in the sense that the firm sells all of its inventory and does not raise its price or it experiences zero demand and does not lower its price.

5. Similarly, Ziv (1993) eliminates mixed strategy equilibria in a Cournot game by restricting the firms’ cost support; see also Novshek and Sonnenschein 1982. Extending the cost support to \([0, a]\) is left for future research.

6. The introduction of demand uncertainty, rather than cost uncertainty, gives rise to the same equilibrium outcome under either the historical cost or fair value rule. We do not incorporate demand uncertainty in the model because we want to eliminate exogenous sources of uncertainty when the firms measure and report their inventory. By eliminating this obvious source of uncertainty, we are able to emphasize the complexity that recognizing the strategic interaction between firms causes.

7. In a Bayesian equilibrium, each firm maximizes its expected profit by choosing a price, given its beliefs about the other firm’s inventory and anticipated price that it deduces from its competitor’s accounting report. See Osborne and Rubinstein 1994 (26) for a formal definition of the Bayesian equilibrium concept.

8. The variance or informativeness of the accounting report in panel D in Figure 3 is determined as follows:

\[
\text{variance} = \frac{1}{2} \left( q_i^l - \frac{q_i^l + q_i^h}{2} \right)^2 + \frac{1}{2} \left( q_i^h - \frac{q_i^l + q_i^h}{2} \right)^2.
\]

9. Credible voluntary communication, however, is possible under some conditions in a multiperiod game, even if the accounting report imperfectly reveals the firm’s capacity (Stocken 2000).

10. To formally define the efficient rationing rule, suppose that firm \(i\)’s price, \(p_i\), is less than firm \(j\)’s price, \(p_j\), and firm \(i\) has an inventory of \(\tilde{q}_i\), where \(\tilde{q}_i \leq D(p_j)\). In this case, firm \(i\) produces and sells a quantity of \(p_i\) equal to its inventory holding \(\tilde{q}_i\) at price \(p_i\).

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and firm $j$ sells $q_j = \min(\overline{q}_j, \max(0, D(p_j) - \overline{q}_j))$ units at price $p_j$. A symmetric formula applies if firm $i$ names a price higher than that named by firm $j$. If, on the other hand, $p_i = p_j$, then firm $i$ sells $q_i = \min(\overline{q}_i, \max(D(p_i)/2, D(p_i) - \overline{q}_i))$ units. The situation is analogous for firm $j$.

References


Discussion of “Strategic Consequences of Historical Cost and Fair Value Measurements”*

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1. Overview

Reis and Stocken (2007) fits within the literature on commitment games in product market competition. As with other studies in this vein, much depends on the efficacy of those commitments and their observability by rival firms. A principal antecedent of this paper is an article by Kreps and Scheinkman 1983 who consider both quantity and price commitments. The basic structure is for firms to simultaneously choose quantities at the first stage and prices at the second stage, resulting in an equilibrium for this game that is equivalent to the Cournot solution to a game in which firms choose quantities and the market-clearing price is implicitly determined by a mythical auctioneer. In particular, they call attention to the crucial importance of timing of decisions and information reception. Our comments will speak mainly to these aspects.

The innovations in Reis and Stocken’s analysis are uncertainty and private information about firm-specific unit costs and disclosure rules regarding communication of first-stage quantity choices. Two such disclosure rules are considered: the product of unit cost and quantity, called historical cost, and the product of expected future price and quantity, called fair value. They show that only the latter communicates quantities perfectly, allowing firms to better coordinate their production by being able to better anticipate each other’s pricing decisions. As a consequence, expected industry production and profits are higher, consumer surplus is lower, and social welfare is higher under fair value accounting than under historical cost accounting.

The paper is beautifully composed and the analysis appears to be entirely correct. In many ways, it is a nice paper to discuss. Because it is so well done, we can and do focus our comments on the contribution.

We agree that in the context analyzed by the authors, this study provides interesting insights with important policy implications. That said, an economic model’s conclusions are only as compelling as the structure necessary to obtain those conclusions. If the assumptions of this study were either plausible or noncritical to the results, then these results would constitute an important contribution to the thinking of policymakers in setting accounting standards.

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Our concerns are that critical assumptions of Reis and Stocken’s model are highly tenuous and that the model is not robust to their relaxation. Thus, we conclude that the model, while both interesting and insightful, nonetheless fails to provide a foundation for accounting policy recommendations. In particular, we doubt that adoption of fair value accounting for inventory would provide the societal benefits predicted by this study.

The principal assumptions of Reis and Stocken’s model with which we take issue are (a) that price must be set once and cannot be adjusted in response to market conditions, (b) that no production occurs between the end of the reporting period and the public release of the accounting report, (c) that the inventory value in the balance sheet corresponds to a single product, and (d) that fair value means expected future cash flows from selling the inventory. We discuss each of these assumptions in detail and further note that industry has generally opposed policies that call for reports more revealing of proprietary information.

Let us first consider what might happen if firms do not commit to prices at the second stage. Clearly, this is a concern in light of the ease with which prices can be adjusted and casual observations of firm’s changing prices in response to prices set by rivals. If firms could instantaneously and costlessly adjust prices, the equilibrium would be fully revealing of unit costs chosen at the earlier stage, in which case the standard Cournot solution would obtain under historical costing as well as fair value accounting. In fact, we suggest that disclosure of first-stage decisions would be a moot issue. The basic insight is that separation of the game into two stages is inconsequential if price commitments can be undone.

Suppose, next, that firms could continue to produce at the same unit cost after reporting their inventories. This seems reasonable, given what may be a considerable lag between the time when contents of financial reports are determined and the time when they are reported. Competitors care about current inventory, not historic inventory. This difference can be strategically manipulated to undo the informativeness of the stale report. We can draw an analogy to a signaling game in which mimicking is costless in one direction. Underreporting production has the strategic advantage of encouraging higher pricing by the rival at the second stage, implying that mimicking is desirable. Hence, all firms have an incentive to choose low inventories, with the result that inventory reports are meaningless.

To be fair, the staleness of financial reports is an issue in all disclosure-commitment games, including several such games that appear in papers we have co-authored. In a broader sense, window dressing might be argued against any alleged strategic effects of accounting reports.

Another concern about the suitability of inventory disclosures as a means of communicating private cost information is the high degree of aggregation that characterizes financial accounting reports. Reported inventories aggregate inventories at different stages in the production process and inventories for different products. This aggregation feature calls into question whether one could invert even fair value inventories to determine costs. Necessarily, such high degrees of aggregation involve noise. As the authors note, Bagwell (1995) shows that strategic commitments are sensitive to even small amounts of noise.
Although Maggi (1999) counters that the presence of private information may serve to restore effects of commitments on rival behavior, it would be a challenging exercise to show that such a tension in the setting for this paper would have a similar effect. Admitting noise due to aggregation would undermine the role of fair value, as well as further undermine the role of historical costing as a communication device; which would dominate seems difficult to determine.

Notwithstanding the authors’ contention that accounting policymakers tend to favor recourse to expected future cash flows to measure fair value, the general approach for inventory in practice is to employ replacement costs. Since there is no dynamic element to unit costs in this study, replacement cost and historical cost are one and the same. Moreover, even if they were different, the key feature of fair value as a perfect communication device is that it depends on equilibrium prices that both firms can deduce. It is hard to see how replacement cost in place of fair value would accomplish this. Possibly, if replacement costs were input market prices observable to both firms, then one could invert to learn quantities. But such an assumption would be inconsistent with firm-specific private cost information.

2. Repricing

In this section, we assume that the firms are not committed to their initial price, but can adjust price in response to market conditions. This seems reasonable in the context of Reis and Stocken’s setting, especially if we ponder real-world applications (such as the flu vaccine example suggested by the authors). Presumably, the sale of the production in this good takes place over a long period of time (months or even years).

If firms are allowed to change price, then a different equilibrium results, one that exactly matches Cournot. To see what happens in this case, we reconsider Reis and Stocken’s second-period problem. Both firms enter the market knowing their own (fixed) inventory quantities, $q_i$ and $q_j$. For simplicity (we shall demonstrate that it does not matter), assume that neither firm knows its competitor’s quantity.

Initially, each firm selects a price, $p_i$ and $p_j$. Upon observing the prices, consumers submit demands to the firms. The firms are then allowed to respond to these demands by raising or lowering their prices. This continues until both firms no longer wish to change their prices.

Our model thus far has enough structure to ensure that only one set of prices could arise in equilibrium, but does not have enough structure to ensure that prices do in fact converge to this unique equilibrium. Thus, we introduce a specific price setting and adjustment rule for the firms to guarantee convergence. Note that there are an infinite number of alternative pricing rules that lead to the same outcome (and no pricing rules that lead to any other outcome).

Assume that firms set initial price by assuming their competitors will set the same price. Then $p_i = a - 2q_j$.

If, as conjectured, the other firm does pick the same price (with the same inventory quantity), then each firm will just sell out at the highest price that can be set while selling out. This clearly would maximize both firms’ profits and would be an equilibrium, so neither firm would choose to reprice.
Now assume that prices differ. Without loss of generality, assume that $p_j < p_i$. Firm $j$ sells out fully, and firm $i$ receives a residual demand. Denoting sales for each company as $q_i$ and $q_j$:

$$q_j = \tilde{q}_j = (a - p_j)/2.$$  
$$q_i = (a - p_i) - p_j$$  
$$= (a - p_i) - (a - p_j)/2$$  
$$= (a - p_i)/2 - (p_i - p_j)/2$$  
$$= \tilde{q}_i - (p_i - p_j)/2 < \tilde{q}_i.$$

The firm charging the higher price fails to sell out its inventory. As Reis and Stocken note, given the parameterization of their model, it is never advantageous to charge a high price and have unsold inventory rather than to charge a lower price and fully sell out. Thus, the current price, $p_i$, is not profit-maximizing. Clearly, the company will cut its price. Assume that the firm’s price adjustment to its demand is to cut price by exactly the excess supply: $p_i^{(2)} = p_i^{(1)} - (\tilde{q}_i - p_i)$, where the superscripts denote successive pricing choices.

Firm $j$ is also unhappy with its low price. The company will receive orders from customers that exceed its supply. These lost customers represent a wasted opportunity, specifically through the fact that a higher price can be charged while still selling out. To speed the convergence process, assume that the firm can observe the other firm’s price (not unreasonable given that consumers can see that price). Then, the appropriate new price is the average market price, $p_j^{(2)} = (p_j^{(1)} + p_j^{(1)})/2$.

With the updated prices, it is easy to see that both firms will charge identical prices and exactly sell out their products. This is an equilibrium and neither firm has an incentive to change price. Thus, only one repricing is necessary to replicate the one-price Walrasian auctioneer market, with $p_j^{(2)} = p_j^{(1)} = a - \tilde{q}_i - \tilde{q}_j$. For most real-world commodity product markets (the type of products modeled by Reis and Stocken), it is reasonable to expect that companies have sufficient time to engage in at least one repricing.

Note that in this model, neither firm has an incentive to “trick” the other company by overpricing (or underpricing) in the first round to induce the other firm to overprice in the second round. If this happened, then the other firm would face insufficient demand in the second round and cut price in a third round. The only effect of either firm defecting from the proposed pricing strategy is to lengthen the convergence process, but it will still end up at the same result.

The only question then is whether any real-world markets reflect an endemic difference in price between competitors that persists over anything more than a very brief period. It is difficult to identify any private market examples of differential pricing that do not reflect differences in quality of goods (which is not the subject of Reis and Stocken’s model). The only common examples of multiple prices of commodity goods involve deliberate underpricing (subsidization) by governments with limited quantities offered to meet consumer demand.

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There are many examples of temporary mispricing with excess supply or demand in the private market — for example, “hot” Christmas toys each year. Prices do not adjust to meet demand and queuing costs arise. However, such examples typically involve an unusually compressed selling period, making price adjustment difficult. The source of uncertainty is fickle consumer demand, not unknown competitor actions, so accounting cannot be helpful in solving the problem. Moreover, the problem in this and similar examples arises precisely because competitor products are poor substitutes. Reis and Stocken assume perfect substitutability, and this substitutability is important for their results.

Finally, it is clear that in the absence of natural impediments to repricing, there is no incentive for the firms to unilaterally impose artificial impediments (precommitments) to repricing. There are many situations in which companies are indeed better off if they can precommit, especially with respect to quantity produced, but there is no incentive in this model for either firm to precommit to price.

The implications of relaxing Reis and Stocken’s precommitment assumption regarding prices are that (a) information about competitor inventories is irrelevant because the same prices will result regardless of what the firms initially know about each other, and (b) the optimal inventory choice is always the Cournot quantity, which corresponds to Reis and Stocken’s “fair value” equilibrium. Thus, in our version of the game, the accounting system is irrelevant.

3. Post-reporting production

When the fiscal year (or quarter) ends and the accounting books are closed, the factories do not shut down. By the time financial statements are published, months have passed. Thus, the inventory quantity numbers, even if they can be inferred from the financials, are out of date by the time they are learned.

This staleness problem is more troublesome than simple noise. The companies, knowing that their competitors will react to stale information, have an incentive to engage in strategic manipulation of the reported numbers, maximizing their deviation from the actual inventory position at the time the numbers are released.

To explore this strategic incentive, assume that production occurs in two stages, pre-report and post-report. The marginal cost of production is the same in both periods. Only pre-report production is included in inventory reported on the balance sheet. Consider the fair value case, where Reis and Stocken have shown that the inventory quantity can be inferred from the inventory value.

We now adapt a simplified version of Reis and Stocken’s model that absorbs the second-period price-setting game into a reduced form for expected (in the first period) price, $p^*$:

\[
p^* = \alpha - \beta(q^b_j + q^a_i) - \gamma q^e_i, \quad \alpha, \beta, \gamma > 0,
\]

where $q^b_i$ and $q^a_i$ are the before and after production levels respectively, and $q^e_i$ is the expected total production quantity conditional on the disclosure of $q^b_j$. $q^e_i$ is what firm $i$ knows firm $j$ will believe firm $i$’s production to be when $j$ sets its price. The
higher production is, the lower price needs to be to sell out. Likewise, the higher “expected” production is, the lower the competitor’s price, and thus the lower your price, needs to be to ensure a sell-out.

Clearly, $q_i^e$ is a function of only $q_i^b$. There are two possibilities. Either $q_i^e$ is independent of $q_i^b$ or $q_i^e$ is increasing in $q_i^b$ (it could be an inverse or non-monotonic relationship, but these are less plausible, and in any event easily refuted as equilibrium beliefs). If $q_i^e$ is independent of $q_i^b$, then companies ignore each other’s accounting reports and the valuation rules do not matter.

Consider the possibility that $dq_i^e/dq_i^b > 0$. In that case, with $\bar{q}_i$ the total production,

$$\frac{dp^*}{dq_i^b} = -\beta - \gamma \frac{dq_i^e}{dq_i^b} < -\beta.$$

$$\frac{dp^*}{dq_i^b} = -\beta.$$

$$\frac{dp^*}{dq_i^b} \bigg|_{q_i^a = q_i^b} = \frac{\delta p^*}{\delta q_i^b} + \frac{\delta p^*}{\delta q_i^a} \frac{\delta q_i^a}{\delta q_i^b} - \frac{\delta p^*}{\delta q_i^b} = - \gamma \frac{dq_i^e}{dq_i^b} < 0.$$

This shows that, holding total production constant, shifting production from post-reporting to pre-reporting causes the expected sales price to fall. Since costs of production are the same either way, it is readily apparent that the larger the fraction of production done prior to the reporting date, the lower the firm’s profits. The optimal strategy is to produce nothing preproduction, regardless of the company’s marginal cost.

It is clear from this that if firms try to infer anything about their competitor’s production from accounting reports, then in the absence of constraints their behavior will adjust to ensure that indeed nothing can be inferred. In this situation, accounting becomes meaningless, no matter how inventories are valued.

An alternative way of interpreting this is in the context of the signaling literature. In a standard signaling game, “good” types distinguish themselves from “bad” types through costly actions that the bad types cannot afford to mimic and are rewarded with more desirable behavior by other agents. This is known as a separating equilibrium. Reis and Stocken’s first-period production game fits the paradigm for a separating equilibrium. Firms signal type through their accounting reports. Since the accounting report must correspond to actual production, it is costly for “bad” firms (paradoxically, those with low production costs) to mimic “good” firms by reporting (manufacturing) low inventory levels. The good types (those with high production costs) are rewarded by their competitors, who charge higher prices in response to the signal.

In our alternative setting, with post-reporting production, it is costless for bad types to mimic good types by underreporting. They can make up for any pre-report...
underproduction later (note that it is costly for the good types to mimic the bad types through overreporting, but this is irrelevant). The consequence of free mimicry is that all firms pretend to be the “best” type, which is a company with such high marginal costs that the optimal level of production is zero. This is a classic pooling equilibrium in which the signal plays no part.

4. Aggregation

Few companies produce exactly one product. Certainly, few public companies do (and private companies do not need to) give detailed financial data by product to their competitors. Even when a firm has only one line of business, it generally makes several different individual products. Mining companies, which would appear to come as close as any type of firm to the commodity-type business envisioned in Reis and Stocken’s model, often extract multiple minerals from the same mine (for example, gold and silver are common by products of copper mining).

If a company has multiple products whose values are aggregated in its reported inventory, then a very strong condition must hold for competitors to be able to disentangle them. All of the company’s products must have perfectly correlated marginal costs of production. If their products experience any idiosyncratic shocks to marginal cost, then the delicate inversion from value to quantity performed by companies in Reis and Stocken’s model becomes impossible.

Instead of financial accounting information, we suspect that firms in many industries rely primarily on nonfinancial sources of information regarding inventories and production levels, including trade publications and industrial espionage. Compared with the noisy information on quantity that can be inferred from the balance sheet, these alternative information channels can be directly focused on the quantity. That being the case, it is unclear what role, if any, inventories as reported in financial statements might play in influencing rival behavior.

5. What is “fair value”?

Reis and Stocken depend on a particular definition of “fair value” for inventories to derive their results. This definition does not comport with market valuation as applied to inventories currently (under lower of cost or market) and seems unlikely to be acceptable to accounting standard-setters.

Reis and Stocken’s fair value is the projected future cash flows derived from the sale of inventory. Lower of cost or market uses this (approximately) as one of three measures used collectively to determine market value. However, the principle measure of market value for inventory is replacement cost, and if generally accepted accounting principles are ever amended to value all inventories at market, replacement cost is likely to be the primary or exclusive way of measuring that value.

In Reis and Stocken’s model, there is no difference between replacement cost and historical cost. Expected future cash flow is essential for Reis and Stocken because it is a monotonic function of expected price that, in turn, is a monotonic function of quantity, which is what allows for an inversion from expected cash flow
to quantity. Replacement cost is incapable of performing the same function (except when historical cost can also perform that function).

Could future cash flow become the measure of inventory market value, to be applied to both increases and decreases in inventory? This seems implausible. The implication would be that the production of goods generates a profit for the company even in the absence of a sale. This is sufficiently troublesome for a manufacturing firm, but even more so for a merchandiser who could book profit just by ordering goods. This would appear to be a recipe for earnings management. At best, one would have to rely on past experience imparting a dynamic element not present in the model.

6. Lobbying history

Finally, we suggest that the underlying notion that competing firms seek to inform in order to coordinate their production seems to be at odds with casual observation. On the contrary, for decades, companies in numerous industries have consistently lobbied the Financial Accounting Standards Board to limit the details in required disclosure to prevent learning by their competitors. Thus, Reis and Stocken’s conclusion that companies would unambiguously benefit from mandatory disclosure of proprietary information must overcome historical evidence suggesting that the companies themselves have a contrary belief. At most, one can argue that of the many tensions that may come to bear in setting financial accounting policy, a desire to coordinate production decisions works in the direction of more informative inventory valuation choices.

7. Concluding remarks

It would be a mistake to dismiss Reis and Stocken’s analysis because the assumptions might not accord with reality or because its policy prescriptions are too narrowly and tenuously based to be plausible for policymakers to adopt. Models are essentially metaphors for key tensions that may influence behavior. Analyzing tensions in a highly structured setting can be illuminating about aspects of information that may affect competition. For example, Reis and Stocken’s results cause us to better appreciate incentives for production that deviates from that reflected by reported inventories or for prices that depart from those initially announced (that is, incentives for defections from proposed equilibrium strategies). Or, if we buy the efficacy of production and price commitments, but are concerned about aggregation and implicit noise, then we can gain a better appreciation for incentives regarding the generation of information outside that contained in financial reports.

As for the “horse race” between historical cost and the fair value concept for inventory accounting, Reis and Stocken have changed the platform for the debate from the rhetorical exchanges in the literature of the 1960s to one that embraces potential real effects on competition. This, we conclude, is a useful step toward a better sense of why accounting valuation rules might matter.
References


