# Continuous Signaling Within Partitions: Capital Structure and the FIFO/LIFO Choice

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*This paper considers a setting in which managers have private information about the values of their firms and can communicate it to uninformed investors through the use of two signals: capital structure and inventory accounting method. We show conditions under which a separating equilibrium with debt alone does not exist. The two-signal equilibrium involves a partitioned separation in which the highest quality firms choose FIFO and the lower quality firms choose LIFO, and all firms then distinguish themselves within these two partitions through capital structure choices. The analysis helps to explain the many observed empirical regularities about firms' capital structure choices and LIFO/FIFO choices and, in addition, produces numerous testable predictions about the relation between capital structure and inventory accounting method.*

## 1. Introduction

We analyze the manager's choice of both an inventory accounting method (LIFO versus FIFO) and capital structure in order to communicate private information about the firm's future cash flows. We derive the conditions under which three different separating equilibria exist: (1) an equilibrium where only capital structure is used as a signal (e.g., as in Ross [1977]); (2) one in which signaling with capital structure alone is feasible, but the cost-efficient equilibrium involves simultaneous use of both signals

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by some firms (e.g., as in Milgrom and Roberts [1986]; Ambarish, John, and Williams [1987]; Ofer and Thakor [1987]; Datar, Feltham, and Hughes [1991]); and (3) an equilibrium in which signaling with capital structure alone is too costly to be feasible, but a separating equilibrium obtains with both signals used simultaneously. It is the last equilibrium that provides a unique new role for a second signal.

The ability of financial decisions such as dividend policy and capital structure to communicate private information has been well established. However, although a similar role for accounting choices has been suggested by Gonedes and Dopuch (1974) and Dye (1985) among others, there has been little formal analysis of this possibility.

The motivation for examining capital structure and LIFO/FIFO as simultaneous signals arises from the natural interaction between these finance and accounting choices. It is frequently asserted (e.g., Zmijewski and Hagerman [1981]; Watts and Zimmerman [1986]) that a manager will select income-increasing accounting methods to ease the restrictions that bond covenants impose on financial decisions. A second interaction between capital structure and accounting relates to taxes. Although the relation of capital structure to taxes is obvious, the relation of accounting method choice to taxes is less so because accounting methods chosen for financial reporting can differ from those chosen for tax purposes. Indeed, a company may select an income-increasing method for financial reporting and an income-decreasing method for taxes. There is, however, an important exception: the IRS tax conformity rule relating to LIFO inventory valuation.[1] Hence, both capital structure and LIFO/FIFO choices have direct effects on tax payments, and it is therefore of interest to examine the interaction of these choices.

Hughes and Schwartz (1988), hereafter H-S, develop a model in which the firm can choose either LIFO or FIFO. They assume that there are two types of firms facing some probability of bankruptcy and derive a separating equilibrium in which the higher quality firm chooses FIFO in order to reveal that its future prospects are good enough that it can afford to lose the tax benefit of LIFO. However, H-S take the firm's debt level as exogenously fixed, which makes it difficult to assess how the firm's LIFO/FIFO choice would be affected if the bankruptcy probability itself were a matter of choice. Another limitation of H-S is that full separation is unattainable when there are more than two firm types. We deal with these two considerations by analyzing the FIFO/LIFO choice under asymmetric information when there are three firm types and capital structure choice is available. In equilibrium,

1. Under this rule, a firm that uses LIFO for tax purposes must also use it for financial reporting.

firms partially pool through their choices of LIFO or FIFO, and then attain full separation through their (continuous) capital structure choices.

Despite the paucity of theory, there is empirical evidence on the effect of the inventory accounting choice on debt. Hunt (1985) finds that firms adopting LIFO have less debt than firms using FIFO, and suggests that FIFO use may be motivated by bond covenant considerations (because it results in higher income). This conclusion is reinforced by Johnson and Dhaliwal (1988), who discover that LIFO abandoners have significantly more debt than control firms. They conclude that the bond covenant effect often dominates tax considerations. Lindahl (1989) estimates cross-sectional and dynamic models of LIFO choice and finds a significantly negative relation between a firm's debt/equity ratio and the use of LIFO. However, Dopuch and Pincus (1988) predict that a firm facing relatively high marginal tax rates might both issue more debt and switch to LIFO, thereby causing a positive association.

The market response to LIFO adoption has received considerable attention, and both positive and negative reactions have been detected.[2] Hand (1993) identifies a sample of firms announcing that they were considering the adoption of LIFO, and examines the stock market reaction to the announcement of the final decision to switch to LIFO or remain at FIFO. He finds that the market reacted negatively to the announced switch to LIFO and positively to the announced nonswitch. Hand's results indicate that a FIFO choice conveys good news, *in spite of* the adverse tax consequences.

The plan of this paper is as follows. The model is developed in Section 2. The full-information equilibrium appears in Section 3. Section 4 characterizes the asymmetric information equilibrium when capital structure is a choice but firms are constrained to use FIFO. The additional choice of inventory method is introduced in Section 5. Finally, Section 6 concludes.

## 2. The Model

We assume that all firms in the economy are initially all equity financed. Each firm requires an investment of $I$ at the current time $t = 0$ in order to generate a random pretax cash flow $x$ at a future point in time, $t = 1$. There are three types of firms that differ only in the expected value of $x$, which is ex post unobservable by investors.[3] The future realization of $x$ is, however, costlessly observable ex post. We denote by $g_i$ the density function of $x$ for

2. For example, Sunder (1973) and Biddle and Lindahl (1982) document positive price changes, whereas Brown (1980) and Ricks (1982) find negative price changes.

3. It is straightforward to extend the analysis to any finite number of types.

the type $i$ firm, where $g_i$ is distributed[4] over $[-\infty,\infty]$. Type 3 has the highest expected value of $x$, type 1 has the lowest value, and type 2 is the intermediate firm. Because the distributions differ only by the means, the following first-order stochastic dominance ordering exists:

$$G_3 < G_2 < G_1 \quad \forall\, x \in \ (-\infty,\infty), \tag{1}$$

where $G_i$ is the cumulative distribution function for the type $i$ firm.

We consider two points in time in the life of the firm. At the current time $t_0$, the manager has private information about the firm's type and takes two actions: issues debt to completely or partially finance the project and selects the LIFO or FIFO method of valuing inventories. At some future time $t_1$, $x$ is realized, taxes are paid, and the debt is repaid, if possible. If the realized cash flow is less than the promised debt payment, the firm reverts to the bondholders and bankruptcy costs are suffered at both the corporate and managerial levels.[5] We assume that the LIFO/FIFO choice affects cash flows (i.e., prices are increasing, and the firm is buying and selling inventory and not "dipping into old LIFO layers" between $t_0$ and $t_1$).

The notation for the analysis is as follows: $\tau$ = the corporate tax rate, $F_c$ = corporate bankruptcy costs, $F_m$ = the manager's personal bankruptcy costs or penalty in the event of bankruptcy, $D$ = the promised debt repayment including interest, $c$ = the coupon rate, and $B_i$ = proceeds from the sale of type $i$ debt, which promises to pay $D$. Finally, we assume that the capital market is competitive, that investors are risk neutral, and that the risk-free rate of interest is zero.

There are three possible future states relating to bankruptcy and taxes: (1) the firm is bankrupt and pays no taxes, (2) the firm is bankrupt and pays taxes, or (3) the firm remains solvent and pays taxes. The firm is bankrupt and pays no taxes when the cash flow is less than the tax-deductible interest payment[6] $cD$, or when $x \leq cD$. Taxes are paid when pretax cash flows exceed the interest, and the firm is bankrupt when after-tax cash flows are

4. Although we permit negative cash flows, we later impose limited liability for shareholders. After the issue of debt, bondholders are considered to be among the general creditors of the firm, some of which are suppliers who do not get paid fully in the case of bankruptcy.

5. Examples of corporate bankruptcy costs are the possible loss of tax-loss carryforwards and other tax shields on bankruptcy (see DeAngelo and Masulis [1980]) as well as the legal and administrative costs of reorganization. With imperfect information about managerial ability, a bankruptcy that causes a displacement of the manager could adversely affect his future wages. Another source of personal bankruptcy costs may be the loss of the manager's ability to capitalize on his investment in firm-specific human capital if he is displaced subsequent to bankruptcy.

6. The specification that only $cD$ is tax-deductible for all firms is an approximation of the reality that only debt interest is tax deductible. We would expect that $c$ might not be independent of $D$ and might therefore vary with firm type. This approximation is necessary for tractability.

less than the remaining principal $D - cD$. Therefore, the firm pays taxes and is bankrupt when $(x - cD)(1 - \tau) < D - cD$, or when

$$cD \leq x < \frac{D(1 - c\tau)}{(1 - \tau)}.$$

The firm then pays taxes and remains solvent when

$$x > \frac{D(1 - c\tau)}{(1 - \tau)}.$$

Henceforth, let $\beta \equiv (1 - c\tau)/(1 - \tau) > 1$.

The market value of a bond issued by a type $i$ firm promising to repay $D$ at maturity is

$$B_i = \int_{-\infty}^{cD} (x - F_c)g_i dx + \int_{cD}^{\beta D} [x(1 - \tau) + cD\tau - F_c]g_i dx + \int_{\beta D}^{\infty} Dg_i dx. \quad (2)$$

The first term on the right side of eq. (2) is the expected value of the non-tax-paying bankrupt firm taken over by the bondholders, the second is the value of the tax-paying bankrupt firm taken over, and the third term is the expected value of the bondholders' claim when the firm remains solvent. The bankruptcy point is $\beta D$ and the debt tax shield is $cD\tau$. Although bondholders bear the corporate bankruptcy costs ex post if $x < \beta D$, shareholders bear these costs ex ante because they are anticipated in bond pricing. The current value of firm $i$ then is the sum of the values of equity and debt, or

$$V_i = \int_{\beta D}^{\infty} [(1 - \tau)(x - cD) + cD - D]g_i dx + B_i. \quad (3)$$

After substitution of eq. (2) and simplification, eq. (3) becomes

$$V_i = \int_{-\infty}^{cD} (x - F_c)g_i dx + \int_{cD}^{\infty} [(1 - \tau)x + cD\tau]g_i dx - \int_{cD}^{\beta D} F_c g_i dx. \quad (4)$$

The manager maximizes his own expected utility, defined over current firm value and expected future personal bankruptcy costs. The expected utility (EU) of the type $i$ manager is

$$\mathrm{EU}_i = V_i - a\int_{-\infty}^{\beta D} F_m g_i dx. \quad (5)$$

In eq. (5), $a > 0$ represents the relative weight that the manager places on the future bankruptcy costs component of his objective function.

Our approach to modeling the effect of LIFO on the firm is motivated by the earlier work of Sunder who stated:

> Thus, the economic consequence of using LIFO in the presence of inflation, is to increase the current net cash flow of the firm. Since the value of a business entity can be represented as the discounted net present value of future cash flows, a change to LIFO also implies a change in the value of the firm, which is positive during inflation. (1976, 287)

We accordingly assume that when a firm switches from FIFO to LIFO, it realizes tax savings that increase cash flows. Although we recognize that the firm must be buying and selling inventory, generating cash flows, and paying taxes in the interval between $t_0$ and $t_1$ in order for the LIFO/FIFO choice to affect cash flows, we focus only on the cash flow at $t_1$ when the debt matures. When a firm switches from FIFO to LIFO, the precise effect on its cash flows resulting from the deferral of taxes is as follows: taxes paid at $t_0$ and in the future are reduced, before-tax cash flows are increased due to the return on the invested tax savings, and the taxes deferred at $t_0$ are repaid at some future time when the firm or its inventory are liquidated. Denoting the density function of future before-tax cash flows for firm $i$ under FIFO as $g_{iF}$, a shift to LIFO results in a new density function, $g_{iL}$. Because the LIFO and FIFO density functions differ only by the means, the following first-order stochastic dominance ordering holds:

$$G_{iL} < G_{iF} \quad \forall\, x \in (-\infty,\infty), \tag{6}$$

where the $G$'s are the associated cumulative distributions. Because a firm of higher quality is more likely to be in tax-paying states in the interval between $t_0$ and inventory liquidation than a firm of lower quality, and therefore receives greater tax benefits associated with LIFO, we assume that the shift in the expected value of future cash flows is related to firm type such that a higher quality firm will experience a greater shift.[7]

## 3. The Manager's Problem under Full Information

### 3.1 First Best Debt Levels

The first best debt level for the manager of firm $i$ is obtained by maximizing eq. (5) with respect to $D_i$. The first-order condition is

7. Although higher quality firms are assumed to experience a greater mean shift, our results are independent of the magnitude of this shift. For example, the results hold even for equal shifts for all types.

$$\frac{\beta(aF_m + Fc)}{\tau c} = \frac{1 - G_i(cD_i^\circ)}{g_i(\beta D_i^\circ)}, \tag{7}$$

where we assume that the left-hand side is a constant for all types.

Verification of the second-order condition shows that $\partial g_i(\beta D_i^\circ)/\partial D_i^\circ \geq 0$ is a sufficient condition for $D_i^\circ$ to be the unique maximizer of eq. (5). This condition will hold under the reasonable restrictions that the distribution of $x$ is unimodal, all firms have positive net present value (NPV) projects, and the amount of debt issued does not exceed the required investment $I$.

By analyzing the first-order condition, eq. (7), we see that the first-best debt level is decreasing in both the corporate and the personal bankruptcy costs and increasing in the corporate tax rate when the rate is less than .5. In addition, the manager issues less debt when he faces personal bankruptcy costs, and there is a unique first-best debt level for the manager of every firm type such that $D_3^\circ > D_2^\circ > D_1^\circ$. (Formal proofs are available on request.)

### 3.2 The Optimal LIFO/FIFO Choice

When LIFO is adopted, the new distribution of cash flows stochastically dominates that of the firm under FIFO. Optimal debt levels for the type $i$ firm are $D_{iF}^\circ$ under FIFO and $D_{iL}^\circ$ under LIFO, which we now compare.

*Proposition 1:* All firm types increase debt when switching from FIFO to LIFO.

The intuition is clear. Because bankruptcy costs and the effective tax rate are unaffected by the switch to LIFO, an improvement in the cash flow distribution causes all managers to reoptimize by issuing more debt.

Proposition 1 describes the interaction of the FIFO/LIFO and capital structure choices under full information. We now examine the interaction of the two choices under asymmetric information.

For the remaining analysis, we set $F_c = 0$ because the analysis is simplified if we assume that $\partial V/\partial D > 0$, which is the case if $F_c = 0$. The results do not change qualitatively as long as corporate bankruptcy costs are small relative to managerial bankruptcy costs.[8]

8. Many of the remaining proofs use the condition that $\partial V/\partial D > 0$, which clearly holds for all levels of debt if $F_c = 0$. When $F_c > 0$, there is an optimal debt level $D_c^\circ$, which maximizes the value of the firm. Proposition 1 shows that the manager's first-best debt level is $D^\circ < D_c^\circ$. Proposition 2 will show that the manager's choice of debt under asymmetric information is $D^* \geq D^\circ$. Therefore, we know that it will be the case that $\partial V/\partial D > 0$ at $D^*$, if $D^* < D_c^\circ$, which will hold for small values of $F_c$.

## 4. The Problem under Asymmetric Information: Capital Structure Choices

We now assume that investors are not able to observe firm type, and examine how capital structure can be used by managers to convey information about their firms when they are restricted to using FIFO for valuing inventories.[9] In a competitive capital market, each firm's current equilibrium market value will be the present value of its expected future cash flows, *conditional* on the beliefs of investors.

Additional notation for the following analysis is as follows: $V_i^\circ$ = the current market value of firm $i$ under the manager's first best debt level $D_i^\circ$, $D_i^*$ = the incentive-compatible debt level for firm $i$, and $V_i^*$ = the current market value of firm $i$ under its incentive-compatible debt level $D_i^*$.

For the remaining analysis, we define $x^*$ as the value of $x$ such that $g_1 = g_2$ for $x = x^*$. We note that $g_1 > g_2 > g_3 \; \forall \; x < x^*$.

*Proposition 2:* When the first best debt levels are not incentive compatible, fully separating, incentive-compatible debt levels exist in which there are unique debt levels $D_3^* > D_2^* > D_1^\circ$ if $D_3^* < x^*$, where $D_i^*$ is the debt level chosen by the type $i$ firm's manager. We call this condition the *debt signaling sufficiency condition*. These debt levels satisfy the conditions for a universally divine sequential equilibrium as specified by Banks and Sobel (1987).

The significance of $x^*$ is that $G_i - G_{i+1}$ is increasing in $x \; \forall \; x < x^*$ and for every $i \in \{1,2\}$. A marginal increase in debt always increases the probability of bankruptcy more for a lower quality firm than for a higher quality firm when the debt levels are less than $x^*$. This intuitive relationship between firm types that is used throughout the analysis is analogous to Spence's (1974) condition that the marginal cost of signaling be negatively correlated with quality.[10]

It is easy to establish that if the incentive-compatible debt levels for types 2 and 3 are not equal to their respective first-best debt levels, then

9. Signaling through a LIFO/FIFO choice is not viable when LIFO cannot be used for taxes, such as prior to 1939 in the United States and currently in Canada.

10. Although Ross (1977) has shown that debt can serve as a fully revealing signal of firm type, he does have a condition restricting the difference between firm types. In Ross, cash flows of a given type $t$ firm are uniformly distributed on $[0,t]$ and there is a continuum of types $t \in [c,d]$. In order to guarantee incentive compatibility, he requires that $d - c$ be less than an upper bound, which is formulated in terms of various parameters of the model. This condition for separation in Ross' model where cash flows are uniformly distributed is analogous to our restriction that $D_3^* < x^*$ when cash flows are unimodally distributed.

they must *exceed* these first-best levels. Because the manager issues less debt than is optimal for the firm due to personal bankruptcy costs, signaling with debt is dissipative only for the manager.

An implication of proposition 2 is that managers cannot use debt to signal firm type if the firms are very different. The technical reason for the nonexistence of an incentive-compatible debt level for type 3 when it is of a sufficiently high quality relative to the other firms has to do with the curvature of the type 1 manager's indifference curve. Its shape is related to the sign of $\partial g_1(\beta D^\circ_1)/\partial D^\circ_1$, in that it is convex in the region where $\partial g_1(\beta D^\circ_1)/\partial D^\circ_1 > 0$ and concave where $\partial g_1(\beta D^\circ_1)/\partial D^\circ_1 < 0$. When type 3 is of such high quality that its market valuation line is quite flat relative to the other types, then its intersection with the indifference curve of the type 2 manager is in the region where the type 1 manager's indifference curve is concave. This *may* lead to a situation in which $D^*_3$ is so large that the type 3 manager prefers the less-costly debt levels of the type 1 and type 2 managers. Thus, a separating equilibrium does not exist. We now show that the LIFO/FIFO choice may restore the existence of a separating equilibrium.

## 5. Capital Structure and the LIFO/FIFO Choice under Asymmetric Information

We showed in Section 3 that, under perfect information, all firms will switch to LIFO and will simultaneously increase debt levels. We observed in Section 4 that debt levels under asymmetric information will exceed first best debt levels. We next look at the change in second-best debt levels when firms switch from FIFO to LIFO under imperfect information.

The following additional notation is necessary: $D^\circ_{iF}$, $D^\circ_{iL}$ = the first-best debt levels for the manager of firm $i$ under FIFO, LIFO; $D^*_{iF}$, $D^*_{iL}$ = the incentive-compatible debt levels under FIFO, LIFO for the manager of firm $i = 2,3$; $V^\circ_{iF}$, $V^\circ_{iL}$ = the values of firm 1 under debt levels $D^\circ_{1F}$, $D^\circ_{1L}$; $V^*_{iF}$, $V^*_{iL}$ = the values of firm $i = 2,3$ under debt levels $D^*_{iF}$, $D^*_{iL}$ ; and $x^*_F$, $x^*_L$ = the values of $x$ for which $g_{1F} = g_{2F}$, $g_{1L} = g_{2L}$.

The results of Section 4 expressed in the preceding notation are that incentive compatible debt levels under FIFO and LIFO are:

| *FIFO* | *LIFO* |
|---|---|
| $D^*_{3F} > D^*_{2F} > D^\circ_{1F}$, | $D^*_{3L} > D^*_{2L} > D^\circ_{1L}$, |
| where $D^*_{3F} > D^\circ_{3F}$ and $D^*_{2F} > D^\circ_{2F}$, | where $D^*_{3L} > D^\circ_{3L}$ and $D^*_{2L} > D^\circ_{2L}$, |
| if $D^*_{3F} < x^*_F$. | if $D^*_{3L} < x^*_L$. |

*Proposition 3:* When all firms switch from FIFO to LIFO, a sufficient condition for incentive compatibility to obtain is that $D^*_{3L} < x^*_L$ (i.e., the debt-signaling sufficiency condition under LIFO). The new incentive compatible debt levels are $D^\circ_{1L} > D^\circ_{1F}$, $D^*_{2L} > D^*_{2F}$, and $D^*_{3L} > D^*_{3F}$.

Proposition 3 means that, if it is incentive compatible for *all* firms to switch to LIFO, then the current market values of all firms will rise due to two factors. First, the move to LIFO yields each firm a direct tax benefit, which increases its value. Second, the LIFO-induced increase in future cash flows leads to higher debt levels, which also increases firm value due to the debt tax shields.[11]

In H-S, high-quality firms signal to investors by remaining at FIFO and foregoing tax benefits. We have shown that, under certain conditions, all firms can switch to LIFO and receive the corresponding tax benefits while continuing to signal with debt. In an efficient signaling equilibrium, a firm will select the least costly combination of mechanisms. We now examine the determination of this optimal combination. Intuitively, incentive compatibility is likely to be more difficult to satisfy when all firms are at LIFO than when they are at FIFO because the LIFO-induced stochastic dominant shift in a firm's payoff distribution creates two sources of incremental value. One benefit is the direct increase in value due to the higher expected cash flow, and the second is the increase in the present value of the debt tax shield due to the reduced probability of bankruptcy. These effects are more pronounced for the higher quality firms, which experience the greatest increase in expected cash flows. Hence, incentives for mimicry are likely to be increased by the switch to LIFO and restoration of incentive compatibility demands that higher quality firms increase their debt levels even further, relative to lower quality firms. The manager of a higher quality firm may find this new incentive-compatible debt level personally unacceptable. By remaining at FIFO while the other firms switch to LIFO, the manager can *reduce* debt below that necessary when all firms were at FIFO. In some cases, then, the expected utility of the manager of a high-quality firm will be greater with FIFO than with LIFO.

*Proposition 4:* There exists a set of parameter values for which the type 3 manager prefers to remain at FIFO when the type 1 and type 2 firms switch to LIFO.

With a set of exogenous parameter values differing from those identified

11. This result provides theoretical support for the suggestion of Dopuch and Pincus (1988) that LIFO choice might be accompanied by increased leverage due to taxes being a confounding variable.

in proposition 4, there are other possibilities. One is that the tax benefits due to LIFO may be so great that the type 3 firm's value with LIFO will exceed the values of the type 1 and type 2 firms by such a significant amount that the $D^*_{3L}$ needed to discourage mimicking by types 1 and 2 exceeds $x^*_L$. As we have argued earlier, this debt level is not incentive compatible because the type 3 manager prefers the allocations of the type 1 and type 2 managers. The next proposition addresses this issue.

*Proposition 5:* (i) There exists a set of parameter values for which $D^*_{3F} < x^*_F$ (i.e., the debt signaling sufficiency condition is satisfied at FIFO), $D^*_{3L} > x^*_L$ (i.e., the debt signaling sufficiency condition is not satisfied at LIFO), and incentive compatibility is not possible with all firms at LIFO.

(ii) A necessary condition for incentive compatibility is that the type 3 firm should remain at FIFO and choose a debt level $D^n_{3F} < D^*_{3F}$.

(iii) If (i) holds, and $D^*_{2L} < x^*_L$, then there exists a universally divine sequential equilibrium in which the type 3 firm chooses FIFO and debt level $D^n_{3F}$, the type 2 firm chooses LIFO and debt level $D^*_{2L}$, and the type 1 firm chooses LIFO and $D^\circ_{1L}$.

This proposition asserts that even though capital structure signaling induces complete separation with FIFO, it may be inadequate to do so with LIFO. Taken together, propositions 4 and 5 identify two situations in which we can consider capital structure and inventory accounting method as joint signals. In one case, it is incentive compatible for all types of firms to switch to LIFO and fully reveal their types by signaling with capital structure. However, the highest quality firm does not switch in equilibrium because its manager's expected utility at FIFO exceeds that at LIFO. In the second case, it is not incentive compatible for all firms to be at LIFO, so the separating equilibrium *necessarily* involves joint signaling with debt and inventory valuation method.

Proposition 3 indicated that an equilibrium in which all firms switch to LIFO may not exist if $D^*_{3L} > x^*_L$ because the attendant high cost of signaling causes the type 3 firm's manager to mimic a lower type firm. According to proposition 5, incentive compatibility can be restored if the highest quality firm remains at FIFO. The manager of the type 3 firm selects the combination of inventory method and debt that minimizes signaling costs. By staying at FIFO, the manager can reduce debt relative to its necessary level when all firms are at FIFO. Remaining at FIFO is value-dissipating, and thus reduces the value of the firm sufficiently so that the type 3 firm's manager is willing to bear the reduced costs of signaling with debt. As such, there is utility enhancement for the manager of the type 3 firm. Although signaling with FIFO is dissipative for both the manager and the firm, debt signaling is dissipative for the manager alone; thus, it is a cost that must be borne by the firm's shareholders in order to make it viable for the manager to reveal his firm's type at $t_0$.

This proposition has a number of implications. First, all firms will not stay at FIFO. Second, firms will often separate through their choices of inventory accounting, with the highest quality firms remaining at FIFO and the lower quality firms switching to LIFO. Third, despite the pooling of some firm types at LIFO, there is complete separation of firms within the pool through their capital structure choices. Thus we have an equilibrium characterization of the manner in which firms make efficient use of the two signals available to them.[12] An important distinction between our model and most bivariate signaling models is that firms of intermediate value signal only with debt in our model, whereas both signals are employed by all but the lowest quality firm in other models.

## 6. Concluding Remarks

The AICPA 1988 survey of accounting methods used by 600 U.S. firms published in the 1989 *Accounting Trends and Techniques* illustrates persistent use of FIFO under inflation. Of the 600 firms, 221 (37 percent) used FIFO exclusively. Of the 379 firms using LIFO, only 60 percent used it for more than 50 percent of inventories. These numbers did not materially change in the four years beginning 1985, during which time there was positive inflation. Therefore, despite the cost of using FIFO under inflation, many firms continue to use FIFO. Moreover, Hand's (1993) empirical results indicate that the choice of FIFO was greeted positively by the stock market. Our model provides a signaling explanation for these observations.

In addition, our model suggests the following empirical predictions:

1. When a firm switches from FIFO to LIFO, it will also increase its debt if it is feasible to do so.[13]
2. If it is not feasible to simultaneously increase debt when switching

12. This result that the highest quality firm stays at FIFO is similar to the Nash equilibrium in H-S. However, because the set of available signals in H-S is smaller than that here, their equilibrium always involves partial pooling when there are more than two types of firms in H-S. Our analysis shows that complete separation is a natural equilibrium outcome, even with three or more types, when the set of available signals is appropriately enriched.

13. In reality, a manager may be prohibited from increasing debt simultaneously with a switch to LIFO due to existing debt covenants.

to LIFO, the market value of existing debt should increase to reflect the reduced probability of bankruptcy.

3. When the choice of LIFO is available and yields incremental tax benefits relative to FIFO, at least some firms within a group of firms (e.g., an industry) will choose LIFO. We show that at least the lowest quality firm will switch to LIFO because it will not bear the cost of signaling with FIFO. The determination of the number of firms that adopt LIFO depends on the cross-sectional diversity of firms.
4. When only some firms within a group switch to LIFO, those firms remaining at FIFO will reduce their debt levels.
5. When firms within a group switch to LIFO, there will be a greater cross-sectional variation in debt levels for the firms at LIFO than when they were at FIFO. This prediction results because LIFO debt levels under asymmetric information exceed FIFO debt levels, and the lowest quality firm always maintains its first-best debt level.

Existing empirical studies examining the relation between inventory accounting choice and capital structure provide mixed results. Lindahl (1989) finds a significantly negative relation between debt and choice of LIFO. Hunt (1985) also finds a negative relation, whereas Morse and Richardson (1983) and Dopuch and Pincus (1988) find no significant association. The underlying assumption in these studies is that there is an optimal inventory choice that depends on existing firm-specific factors. In reality, the choice is constrained in that a firm can adopt LIFO at any time, but cannot abandon LIFO for FIFO without IRS approval. In addition, a return to FIFO requires paying to the IRS all past LIFO tax savings. There has been no empirical study of a simultaneous or lagged change in capital structure associated with the adoption of LIFO or the retention of FIFO when other firms adopt LIFO, which is what is required in a test of our theory. We, therefore, believe that our major predictions remain to be tested.

Johnson and Dhaliwal (1988) examine characteristics of 87 firms that abandoned LIFO in the period 1950–83. They find that these firms have significantly more debt than a sample of comparison firms. They suggest that firms that are highly leveraged are more likely to be close to violating bond covenants and a switch to FIFO will increase reported income. An alternative reason for the observed association is that the firms that are more highly leveraged are the higher quality firms and that it is these precise firms that switch to FIFO to reduce signaling costs. Although this study provides tentative support for our results, it cannot be interpreted as a direct test of our model because Johnson and Dhaliwal do not investigate the changes in capital structure associated with LIFO abandonment that we predict.

In a perfect market, we would expect to see all firms in the same industry using the same inventory accounting methods because they face the same inflation rate, changes in demand, and real changes in costs of production. However, Brown (1980) finds that the proportion of firms adopting LIFO in 1974 differs across industries. Excerpts from Brown follow (1980, 46, table 1):

| *Industry* | *Number of Firms Adopting LIFO* | *Number of Firms Retaining FIFO* |
|---|---|---|
| Consumer goods—health care | 0 | 4 |
| Chemicals | 6 | 5 |
| Industrial equipment | 14 | 7 |
| Metals—nonferrous | 2 | 0 |

Although these data are puzzling in a symmetric information setting, they are consistent with our signaling model under asymmetric information when the higher quality firms retain FIFO. A direct test of our model would be to examine the capital structure changes subsequent to all or some firms in an industry adopting LIFO for the specific industries studied by Brown.

Our results regarding capital structure provide one perspective on empirically observed interindustry differences in leverage ratios. We find that the tax benefits available from a particular choice of an inventory accounting method impinge significantly on the firm's capital structure choice. As these benefits may vary systematically across industries, so will capital structure. More generally, in an asymmetric information setting, the cost-benefit trade-off of capital structure as a signal will be affected by a variety of other accounting and financial decisions, many of which will be based on industry-specific cost-benefit trade-offs.

## APPENDIX

### Proof of Proposition 1

It follows from the first-order conditions that:

$$\frac{1 - G_{iF}(cD^{\circ}_{iF})}{g_{iF}(\beta D^{\circ}_{iF})} = \frac{1 - G_{iL}(cD^{\circ}_{iL})}{g_{iL}(\beta D^{\circ}_{iL})} \quad \forall i. \tag{A1}$$

The first-order stochastic dominance relation, eq. (6), and the second-order conditions imply

$$\frac{1 - G_{iL}(cD^{\circ}_{iF})}{g_{iL}(\beta D^{\circ}_{iF})} > \frac{1 - G_{iF}(cD^{\circ}_{iF})}{g_{iF}(\beta D^{\circ}_{iF})} \quad \forall i. \tag{A2}$$

Combining eqs. (A1) and (A2), it is the case that

$$\frac{1 - G_{iL}(cD^{\circ}_{iF})}{g_{iL}(\beta D^{\circ}_{iF})} > \frac{1 - G_{iL}(cD^{\circ}_{iL})}{g_{iL}(\beta D^{\circ}_{iL})} \quad \forall i. \tag{A3}$$

The desired result follows because the hazard function in eq. (A3) is decreasing in $D$. Q.E.D.

For the remaining proofs, we provide only brief sketches. Detailed proofs are available on request from the authors.

### Sketch of Proof of Proposition 2

The proof is standard. The lowest quality firm (type 1) receives its first best allocation. As long as the incentive-compatible debt level for the highest quality firm (type 3) is less than $x^*$, the indifference curves for all firm types have the necessary single-crossing property. Thus, higher valued firms choose higher debt levels. The idea in the proof of universal divinity is to consider four possible types of defections from the equilibrium: (i) $D < D^{\circ}_{1F}$, (ii) $D \in (D^{\circ}_{1F}, D^{*}_{2F})$, (iii) $D \in (D^{*}_{2F}, D^{*}_{3F})$, and (iv) $D > D^{*}_{3F}$ . Let $S_i$ be the set of market responses that induces the manager of a type $i$ firm to defect. For (i) and (ii) we show that $S_3 \subset S_2 \subset S_1$, so that by the universal divinity criterion, investors must assign probability one that the defector is a type 1 manager. Thus, the defector's firm will be valued as a type 1 firm. Given this, no firm defects. For (iii), we show that $S_3 \subset S_2$, which means investors must assign zero probability that the defection is by a type 3 firm's manager. With a best response by investors with these beliefs, however, the incentive compatibility conditions immediately imply that no one will defect. Finally for (iv), we see that $S_1 = S_2 = S_3 = \emptyset$, the null set, because there exists no belief on the part of investors that induces any firm to defect.

### Sketch of Proof of Proposition 3

The proof involves first showing that $D^{*}_{2L} > D^{*}_{2F}$ . To show this, it must be shown that, if the type 2 firm's manager keeps his firm's debt level at $D^{*}_{2F}$ when he switches to LIFO, the type 1 firm's manager will mimic him. This is shown by proving that

$$\frac{\partial}{\partial \mu} [V_{2F}^* \; - \; aF_m G_{1F}(\beta D_{2F}^*)] \; > \frac{d}{d\mu} [V_{1F}^\circ \; - \; aF_m G_{1F}(\beta D_{1F}^\circ].$$

The left-hand side of the preceding inequality is a *partial* derivative because it is the increase in the expected utility of the type 1 firm's manager from mimicking the type 2 firm's manager when the latter switches to LIFO *without* changing his firm's debt. On the right-hand side, a *total* derivative is taken because the type 1 manager's first-best utility increases from switching to LIFO both because of an increase in the mean cash flow and an increase in debt. This proof involves exploiting the first order stochastic dominance (FOSD) shifts in the distributions of cash flows induced by switching to LIFO. The proof holds as long as the LIFO-induced mean shift is no greater for the lower quality firms than it is for the higher quality firms.

**Sketch of Proof of Proposition 4**

*Part 1.* First we prove that there are parameter values for which, if the type 1 firm's manager gains enough by switching from FIFO to LIFO, the type 2 firm's manager also prefers to switch. We want to show that

$$V_{2L}^* \; - \; aF_m G_{2L}(\beta D_{2L}^*) \; > V_{2F}^* \; - \; aF_m G_{2F}(\beta D_{2F}^*). \qquad \text{(A4)}$$

This inequality can be shown to hold by substitutions for $V_{2L}^*$ and $V_{2F}^*$ from the nonmimicry conditions for $D_{2L}^*$ and $D_{2F}^*$, so that the type 1 manager does not mimic the type 2 manager in each case.

*Part 2.* Next we show that there are parameter values for which the type 3 manager prefers to remain at FIFO when types 1 and 2 switch to LIFO. We need only to provide an example in which this is true. Let $x$ be normally distributed with a standard deviation of 1 for every firm type. The means of $x$ are 2.0, 2.2, and 2.3 for the type 1, type 2, and type 3 firms, respectively, when they all choose FIFO. The respective mean shifts when moving to LIFO are 0.05, 0.06, and 0.07. Other parameter values are $c$ = 0.1, $aF_m = 0.1$, $\tau = 0.35$, and $F_c = 0.415$. With these exogenous parameter values, we have $x_F^* = 2.1$ and $x_L^* = 2.155$. In the all-FIFO equilibrium, $D_{1F}^\circ = 1.054$, $D_{2F}^* = 1.678$, and $D_{3F}^* = 2.023$, with expected utilities 1.1622, 1.1696, and 1.1726, respectively. If all firms are at LIFO, then $D_{1L}^\circ = 1.092$, $D_{2L}^* = 1.748$, and $D_{3L}^* = 2.144$, with expected utilities 1.1951, 1.2028, and 1.2058. If the type 1 and type 2 firms switch to LIFO while the type 3 firm remains at FIFO, then $D_{3F}^n = 1.871$, and the type 3 manager's expected utility is 1.2063. Clearly, the type 3 manager is better off at FIFO than at LIFO when the type 1 and type 2 managers switch to LIFO.

**Sketch of Proof of Proposition 5**

*Proof of (i)*: We need only to provide an example in which this is true. Consider the following numerical example with parameter values with a normal distribution of $x$. This distribution has a standard deviation of 1 for every firm type. The means of $x$ are 2, 2.2, and 2.3 for the type 1, type 2, and type 3 firms, respectively, when they all choose FIFO. The respective mean shifts when moving to LIFO are 0.05, 0.06, and 0.07. The other parameters are $c = 0.10$, $aF_m = 0.1$, $\tau = 0.35$, and $F_c = 0.41$. (Similar examples can be constructed with $F_c = 0$.) With these parameter values, $x_F^* = 2.100$ and $x_L^* = 2.155$. The equilibrium with all firms at FIFO is $D_{1F}^\circ = 1.069$, $D_{2F}^* = 1.698$, and $D_{3F}^* = 2.054$. If all firms are at LIFO, then $D_{1L}^\circ = 1.108$, $D_{2L}^* = 1.769$, and the debt level choice of the type 3 manager, which precludes mimicking by the type 1 and type 2 firms' managers, is $D_{3L}^* = 2.179$. Therefore, $D_{3F}^* < x_F^*$, but $D_{3L}^* > x_L^*$ . The expected utility of the type 3 firm's manager at $D_{3L}^*$ is 1.2034. The manager of the type 3 firm can achieve an expected utility of 1.2039 by mimicking the type 1 manager and issuing $D_{1L}^\circ$, or 1.2047, by mimicking the type 2 manager and issuing $D_{2L}^*$ . Therefore, the all-LIFO allocation is not incentive compatible. The universally divine sequential equilibrium when all firms can choose debt levels as well as LIFO or FIFO involves the type 1 and type 2 firms' managers choosing LIFO with $D_{1L}^\circ = 1.108$ and $D_{2L}^* = 1.769$ and the type 3 firm choosing FIFO with $D_{3F}^n = 1.896$ (which is less than $x_F^*$ and $D_{3F}^*$). The equilibrium firm values are $V_{1L}^\circ = 1.227$, $V_{2L}^* = 1.265$, and $V_{3F}^n = 1.274$, and the equilibrium expected utilities are 1.193, 1.201, and 1.204 for the managers of the type 1, type 2, and type 3 firms, respectively.

*Proof of (ii)*: First, it must be shown that, if the type 3 firm remains at FIFO and chooses a new FIFO debt level $D_{3F}^n$ when the types 1 and 2 switch to LIFO, then incentive compatibility requires that

$$G_{3F}(\beta D_{3F}^n) > G_{3L}(\beta D_{2L}^*) \text{ and } V_{3F}^n > V_{2L}^*.$$

Having established this, we recall that if $D_3^* > x^*$, incentive compatibility may break down. With this in hand, it must be shown that the type 3 firm can remain at FIFO and signal quality with an incentive compatible $D_{3F}^n$, where $D_{3F}^n < D_{3F}^*$ . Critical steps in establishing the incentive compatibility of $D^n_{3F}$ are using the result that $G_{3F}(\beta D^n_{3F}) > G_{3L}(\beta D^*_{2L})$, and $V^n_{3F} > V^*_{2L}$. The proof that $D^n_{3F} < D^*_{3F}$ makes use of the fact that $D^*_{3F} < x^*_F$.

*Proof of (iii)*: The idea is to consider six possible types of defections from the equilibrium: (i) $D < D^n_{3F}$ and FIFO; (ii) $D > D^n_{3F}$ and FIFO; (iii) $D < D^\circ_{1L}$ and LIFO; (iv) $D \in (D^\circ_{1L}, \min\{D^*_{2L}, D^n_{3F}\})$ and LIFO; (v) $D \in (\min\{D^*_{2L}, D^n_{3F}\}, \max\{D^*_{2L}, D^n_{3F}\})$ and LIFO; and (vi) $D > \max\{D^*_{2L}, D^n_{3F}\}$ and LIFO. Let $S^j_i$ be the set of market responses that induces the manager of a type $i$ firm to defect to inventory choice $j$ ($j = F, L$). For (i), we show that $S^F_3 \subset S^F_2 \subset S^F_1$, so investors assign probability one that the defector is a type 1 manager. For (ii), we prove that $S^F_1 = S^F_2 = S^F_1 = \emptyset$, the null set, because there exists no belief on the part of investors that induces any firm to defect. In cases (iii) and (iv), $S^L_3 \subset S^L_2 \subset S^L_1$, and investors believe with probability one that a defector is the type 1 manager. For (v) and (vi), we show $S^L_3 \subset S^L_2$, implying that investors believe that the probability is zero that a defector is a type 3 manager.

## REFERENCES


Ambarish, R., K. John, and J. Williams. 1987. "Efficient Signalling with Dividends and Investment." *Journal of Finance* 42 (June): 321–344.

Banks, J. S., and J. Sobel. 1987. "Equilibrium Selection in Signaling Games." *Econometrica* 5 (May): 647–661.

Biddle, G., and F. Lindahl. (1982). "Stock Price Reactions to LIFO Adoptions: The Association Between Excess Returns and LIFO Tax Savings." *Journal of Accounting Research* 20 (Autumn): 551–588.

Brown, R. 1980. "Short-Range Market Reaction to Changes to LIFO Accounting Using Preliminary Earnings Announcement Dates." *Journal of Accounting Research* 18 (Spring): 38–63.

Datar, S. M., G. A. Feltham, and J. S. Hughes. 1991. "The Role of Audits and Audit Quality in Valuing New Issues." *Journal of Accounting and Economics* 14 (March): 3–49.

DeAngelo, H., and R. W. Masulis. 1980. "Optimal Capital Structure Under Corporate and Personal Taxation." *Journal of Financial Economics* 8 (March): 39–65.

Dopuch, N., and M. Pincus. 1988. "Evidence on the Choice of Inventory Accounting Methods: LIFO Versus FIFO." *Journal of Accounting Research* 26 (Spring): 28–59.

Dye, R. 1985. "Strategic Accounting Choice and the Effects of Alternative Financial Reporting Requirements." *Journal of Accounting Research* 23 (Autumn): 544–574.

Gonedes, N., and N. Dopuch. 1974. "Capital Market Equilibrium, Information Production, and Selecting Accounting Techniques: Theoretical Framework and Review of Empirical Work." *Journal of Accounting Research* 12 (Supplement): 48–129.

Hand, J. 1993. "Resolving LIFO Uncertainty: A Theoretical and Empirical Reexamination of 1974–75 LIFO Adoption and Nonadoptions." *Journal of Accounting Research* 31 (Spring): 21–49.

Hughes, P. J., and E. S. Schwartz. 1988. "The LIFO/FIFO Choice: An Asymmetric Information Approach." *Journal of Accounting Research* 26 (Supplement): 41–62.

Hunt, H. 1985. "Potential Determinants of Corporate Inventory Accounting Decisions." *Journal of Accounting Research* 23 (Autumn): 448–467.

Johnson, W. B., and D. S. Dhaliwal. 1988. "LIFO Abandonment." *Journal of Accounting Research* 26 (Autumn): 236–272.

Lindahl, F. W. 1989. "Dynamic Analysis of Inventory Accounting Choice." *Journal of Accounting Research* 27 (Autumn): 201–226.

Milgrom, P., and J. Roberts. 1986. "Price and Advertising Signals of Product Quality." *Journal of Political Economy* 94: 796–821.

Morse, D., and G. Richardson. 1983. "The LIFO/FIFO Decision." *Journal of Accounting Research* 21 (Spring): 106–127.

Ofer, R., and A. V. Thakor. 1987. "A Theory of Stock Price Responses to Alternative Corporate Cash

Disbursement Methods: Stock Repurchases and Dividends." *Journal of Finance* 42 (June): 365–394.

Ricks, W. 1982. "The Market's Response to the 1974 LIFO Adoptions." *Journal of Accounting Research* 20 (Autumn): 367–387.

Ross, S. 1977. "The Determination of Financial Structure: The Incentive Signalling Approach." *Bell Journal of Economics* 8 (Spring): 23–40.

Spence, M. 1974. "Competitive and Optimal Responses to Signals: An Analysis of Efficiency and Distribution." *Journal of Economic Theory*, 7: 296–332.

Sunder, S. 1973. "Relationship Between Accounting Changes and Stock Prices: Problems of Measurement and Some Empirical Evidence." *Journal of Accounting Research* 11 (Supplement): 1–45.

Sunder, S. 1976. "A Note on Estimating the Economic Impact of the LIFO Method of Inventory Valuation." *The Accounting Review* 51 (April): 287–291.

Watts, R., and J. Zimmerman. 1986. *Positive Accounting Theory*. Englewood Cliffs, N.J.: Prentice-Hall.

Zmijewski, M., and R. Hagerman. 1981. "An Income Strategy Approach to the Positive Theory of Accounting Standard Setting/Choice." *Journal of Accounting and Economics* 3 (August): 129–149.