The relation between earnings and cash flows

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A simple model of earnings, cash flows and accruals is developed by assuming a random walk sales process, variable and fixed costs, accounts receivable and payable, and inventory and applying the accounting process. The model implies earnings better predicts future operating cash flows than does current operating cash flows and the difference varies with the operating cash cycle. Also, the model is used to predict serial and cross-correlations of each firm's series. The implications and predictions are tested on a 1337 firm sample over 1963-1992. Both earnings/cash flow forecast implications and correlation predictions are generally consistent with the data.

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The relation between earnings and cash flows

1. Introduction

Earnings occupy a central position in accounting. It is accounting's summary measure of a firm's performance. Despite theoretical models that value cash flows, accounting earnings is widely used in share valuation and to measure performance in management and debt contracts.

Various explanations have been advanced to explain the prominence of accounting earnings and the reasons for its usage. An example is that earnings reflects cash flow forecasts (e.g., Beaver, 1989, p. 98; and Dechow, 1994) and has a higher correlation with value than current does cash flow (e.g., Watts, 1977; and Dechow, 1994). In this paper we discuss the use of accounting earnings in contracts, reasons for its prominence and the implications for inclusion of cash flow forecasts in earnings. One prediction that emerges is that earnings' inclusion of those forecasts causes earnings to be a better forecast of (and so a better proxy for) future cash flows than current cash flows. This can help explain why earnings is often used instead of operating cash flows in valuation models and performance measures.

Based on the discussion of contracting's implications for earnings calculation, we model operating cash flows and the formal accounting process by which forecasted future operating cash flows are incorporated in earnings. The modeling enables us to generate specific integrated predictions for: i) the relative abilities of earnings and operating cash flows to predict future operating cash flows; and ii) firms' time series properties of operating cash flows, accruals and earnings. We also predict cross-sectional variation in the relative forecast-abilities and correlations. The predictions are tested both in- and out-of-sample and are generally consistent with the evidence.

Dechow (1994) shows working capital accruals offset negative serial correlation in cash flow changes to produce first differences in earnings that are approximately serially uncorrelated.¹ She also shows that in offsetting serial correlation accruals increase earnings' association with firm value. One of this paper's contributions is to explain the negative serial correlation in operating cash flow changes in particular and the time series properties of earnings, operating cash flows and accruals in general. A second contribution is to explicitly model how the accounting process offsets the negative correlation in operating cash flow changes to produce earnings changes that are less serially correlated.

¹Many researchers have however documented some deviations from the random walk property, for example, Brooks and Buckmaster (1976) and more recently Finger (1994) and Ramakrishnan and Thomas (1995).

The third contribution is to explain why, and show empirically that, accounting earnings are a better predictor of future operating cash flows than current operating cash flows.

The next section discusses contractual use of accounting earnings and implications for the inclusion of cash flow forecasts in earnings and the relative abilities of earnings and cash flows to forecast future earnings. Section 3 models operating cash flows and the accounting process by which operating cash flow forecasts are incorporated in earnings. Using observed point estimates of such parameters as average profit on sales, section 3 generates predictions for the relative abilities of earnings and operating cash flows to predict future operating cash flows and for the average time series properties of operating cash flows, accruals and earnings. Section 4 compares the relative abilities of earnings and operating cash flows to predict future operating cash flows. It also compares average predicted earnings, operating cash flows and accruals correlations to average estimated correlations for a large sample of firms. In addition, section 4 estimates the cross-sectional correlation between predicted correlations and actual correlation estimates. Section 5 describes modifications to the operating cash flow and accounting model to incorporate the effects of costs that do not vary with sales (fixed costs). The changes to the model are motivated, in part, by the divergence between the actual correlations and those predicted by the model. Section 6 investigates whether the implications of the modified model are consistent with the evidence. A summary and conclusions are presented in section 7 along with suggestions for future research.

2. Contracts and accounting earnings

This section discusses the development of the contracting literature and contractual uses of accounting. It develops implications for relative abilities of earnings and cash flows to forecast future cash flows and for the times series properties of earnings and cash flows.

The modern economic theory of the firm views the firm as a set of contracts between a multitude of parties. The underlying hypothesis is that the firm's "contractual designs, both implicit and explicit, are created to minimize transactions costs between specialized factors of production" (Holmstrom and Tirole, 1989, p. 63; see also Alchian, 1950; Stigler, 1951; and Fama and Jensen, 1983). While there are questions about matters such as how the efficient arrangements are achieved, the postulate does provide substantial discipline to the analysis (see Holmstrom and Tirole, 1989, p. 64). Since audited accounting numbers have been used in firm contractual designs for many centuries (see for example, Watts and Zimmerman, 1983), and continue to be used in those designs, it is likely that assuming such use is efficient will also be productive to accounting theory.

Prior to the US Securities Acts contractual uses of accounting (“stewardship”) were considered the prime reasons for the calculation of accounting earnings. For example, Leake (1912, pp. 1-2) lists management’s requirement to ascertain and distribute earnings according to the differential rights of the various classes of capital and profit sharing schemes as the leading two reasons for calculating earnings (other reasons given by Leake are income taxes and public utility regulation). Given contractual use was the prime reason for the calculation of earnings and earnings were used for contracting for many centuries, the theory of firm approach would begin the analysis by assuming that prior to the Securities Acts, earnings was calculated in an efficient fashion for contracting purposes (after abstracting from income tax and utility regulation effects). Since at the beginning of the century, many of the current major accruals were common practice (particularly major working capital accruals — inventory and accounts receivable and payable) it seems reasonable to extend the efficiency implication to the current calculation of earnings (particularly working capital accruals). In this section we make the efficiency assumption and sketch an ex post explanation for the nature of the earnings calculation.

Contracts tend to use a single earnings number that is either the reported earnings or a transformation of reported earnings. For example, private debt contracts use reported earnings with some GAAP measurement rules “undone” (e.g., equity accounting for subsidiaries — see Leftwich, 1983, p. 25). And, CEO bonus plans use earnings (or transformations of earnings such as returns on invested capital) to determine 80% of CEO bonuses (Hay, 1991; Holthausen, Larcker and Sloan, 1995). It is interesting to ask why it is efficient for contracts to use a single benchmark earnings measure as a starting point for contractual provisions.

Leftwich (1983, p. 25) suggests private lending contracts use GAAP earnings as a starting point because it reduces contract negotiation and record-keeping costs. Watts and Zimmerman (1986, pp. 205-207) argue sets of accepted rules for calculating earnings for various industries evolved prior to the Securities Acts and formal GAAP. A relatively standard set of accepted rules for calculating earnings could (like GAAP) reduce contract negotiation and record-keeping costs.

Use of a single relatively standardized earnings measure in multiple contracts could also reduce agency costs. Watts and Zimmerman (1986, p. 247) argue the use of audited earnings in multiple contracts (and also for regulatory purposes) reduces management incentives to manipulate earnings. In addition, such use of earnings could reduce enforcement costs. To the extent the contracts rely on courts for enforcement, their

performance measures have to be verifiable (see Tirole, 1990, p. 38).² And, there is a demand for monitors to verify the numbers. Relatively standardized procedures for calculating earnings reduce the cost of verifying the calculation. Of course, standardization reduces the ability to customize earnings and performance measures to particular circumstances. Some of those costs are presumably offset by modification of the earnings performance measure in particular contracts and those that remain are presumably less than the savings.

Performance measures other than earnings are also used in contracts, particularly in compensation contracts. For example, approximately 20% of bonus determination is based on individual and nonfinancial measures such as product quality (see Holthausen, Larcker and Sloan, 1995, p. 36). And stock-price-based compensation (e.g. stock option plans) is also used to incent managers. To that extent, one wouldn't expect earnings to necessarily have all the characteristics of an ideal performance measure for compensation purposes. For example, earnings may not reflect future cash flow effects of managers' actions because the stock price will impound those expected effects. But, the calculation of earnings is relatively standardized, applying to both traded and untraded firms. This suggests earnings will tend to have the desired characteristics of performance measures.

A desirable characteristic of a performance measure is that it be timely, i.e., measure the effect of the manager's actions on firm value at the time those actions are taken (Holmstrom, 1982). This suggests earnings should incorporate the future cash flow effects of managers' actions. If this was all there were to the determination of earnings, we could understand the robust result from thirty years of evidence that, for shorter horizons, average annual earnings is relatively well-described by a random walk (see Watts and Zimmerman, 1986, chapter 6).³ Except for discounting, earnings would, like the stock price, capitalize future cash flow effects and earnings changes would tend to be uncorrelated.

The verifiability requirement prevents the full capitalization of future cash flow effects in earnings. When future net cash inflows are highly probable from an outlay, but their magnitude is not verifiable, the accrual process generally excludes the outlay from current earnings and capitalizes the cost as an asset (e.g., cash outlays for the purchase of inventory or plant). The effect of the exclusion of future cash inflows and their associated current outlays from earnings on the time series properties of earnings is 'a priori' unclear. However, we expect the *inclusion* of verifiable anticipated future cash flows in earnings

² According to the FASB Statement of Financial Accounting Concepts No. 2 (1980), paragraph 89 "verifiability means no more than that several measurers are likely to obtain the same measure."

(such as credit sales) and the matching of outflows (e.g., those related to cost of goods sold) to the inflows to cause earnings to be *closer* to a random walk (have less serial correlation in its changes) than cash flows. We also expect inclusion of verifiable anticipated future cash flows and matching of outflows to increase earnings' ability to predict future cash flows so that current earnings is a better predictor of future cash flows than are current cash flows. We provide support for both expectations in the simple model of firms' cash flows, accruals and earnings presented in the next section (section 3).

In cases where a cash outlay is made but the future cash benefits are not verifiable, highly likely or easily determinable, the accrual process does not reflect the future benefits in earnings or capitalize their value as assets. Instead, the cash outflow is immediately expensed through earnings (e.g., expenditures on research and development or administrative expenditures). In section 5 we extend the model to allow for the existence of such outlays assuming they do not affect cash inflows in immediate future periods and do not vary with current sales (are fixed costs). The model predicts such fixed costs increase the correlation between earnings and operating cash flow changes while reducing the ability of earnings to predict future cash flows. Earnings' ability to predict future cash flows relative to that of current cash flows is unchanged. Not expensing these types of outlays would ameliorate the reduction in earnings' ability to predict future cash flow *if* it is assumed the outlays' capitalization does not change management behavior.

FASB Statement of Financial Accounting Concepts 5 (1984), paragraphs 36 and 37, describes earnings in a fashion consistent with the interpretation of the effects of contracting on accruals and earnings:

“36. Earnings is a measure of performance during a period that is concerned primarily with the extent to which asset inflows associated with cash-to-cash cycles substantially completed (or completed) during the period exceed (or are less than) asset inflows associated, directly or indirectly, with the same cycles. Both an entity's ongoing major or central activities and its incidental or peripheral transactions involve a number of overlapping cash-to-cash cycles of different lengths. At any time, a significant proportion of those cycles is normally incomplete, and prospects for their successful completion and amounts of related revenues, expenses, gains, and losses vary in degree of uncertainty. *Estimating those uncertain results of incomplete cycles is costly and involves risks, but the benefits of timely financial reporting based on sales*

³Researchers have, however, documented some deviations from the random walk property, for example, Brooks and Buckmaster (1976) and more recently Finger (1994) and Ramakrishnan and Thomas (1995).

or other more relevant events, rather than on cash receipts or other less relevant events, out weigh those costs and risks.

37. *Final results of incomplete cycles usually can be reliably measured at some point of substantial completion (for example, at the time of sale, usually meaning delivery) or sometimes earlier in the cycle (for example, as work proceeds on certain long-term construction-type contracts), so it is usually not necessary to delay recognition until the point of full completion (for example, until the receivables have been collected and warranty obligations have been satisfied)... (emphasis added)."*

The effects of accruals on the time series properties of annual earnings and the predictability of future cash flows are likely to be more readily observable for working capital accruals. For the majority of firms the cycle from outlay of cash for purchases to receipt of cash from sales (which we call the "operating cash cycle") is much shorter than the cycle from outlay of cash for long-term investments to receipt of cash inflows from the investments (the "investment cycle"). Working capital accruals (primarily accounts receivable, accounts payable and inventory) tend to shift operating cash flows across adjacent years so that their effects are observable in first order serial correlations and one-year-ahead forecasts. Investment accruals (e.g., the cost of a plant) are associated with cash flows over much longer and more variable time periods. For that reason in this paper we model and investigate the effect of working capital accruals on the prediction of, and serial correlation in, operating cash flows; cash flows after removing investment and financing accruals. However, note that Dechow (1994) finds working capital accruals contribute more than investment and financing accruals to offsetting negative first-order serial correlation in cash flows.

3. A simple model of earnings, operating cash flows and accruals

In this section we develop a simple model of operating cash flows and the accounting process by which operating cash flow forecasts are incorporated into accounting earnings. The model explains why operating cash flow changes have negative serial correlation and how earnings incorporate the negative serial correlation to become a better forecast of future operating cash flows than current operating cash flows. The model also explains other time series properties of earnings, operating cash flows and accruals. Further, the model provides predictions as to how the relative forecast abilities of earnings and operating cash flows vary across firms and explicit predictions for the earnings, operating cash flow and accruals correlations. In section 5 we include fixed costs in the model to explain the small negative serial correlation that is observed for earnings changes

and some other properties of accruals and cash flows. Sections 4 and 6 provide tests of these predictions.

3.1 The simple model

We begin with an assumption about the sales generating process rather than the operating cash flow generating process because the sales contract determines both the timing and amount of the cash inflows (and often related cash outflows) and the recognition of earnings. The sales contract specifies when and under what conditions the customer has to pay. Those conditions determine the pattern of cash receipts and so the sales contract is more primitive than the cash receipts. The sales conditions also determine when a future cash inflow is verifiable and so included in earnings (along with associated cash outflows). Usually that inclusion occurs when under the sales contract the good is delivered and title passed, or the service complete, and a legal claim for the cash exists. However, in certain industries (e.g., construction or mining) the sales contract may make certain payments highly likely and generate the recognition of sales and earnings even when title has not passed. Consistent with Statement of Concepts 5 paragraph 37 (see above), we assume recognition of a sale indicates verifiable future cash inflows under the sales contract.

We assume sales for period t , S_t , follows a random walk process:

$$S_t = S_{t-1} + \varepsilon_t \quad (1)$$

where ε_t is a random variable with variance σ^2 and $\text{cov}(\varepsilon_t, \varepsilon_{t-\tau}) = 0$ for $|\tau| > 0$. This assumption is approximately descriptive for the average firm (see Ball and Watts, 1972, p. 679). Further, the average serial correlation in sales changes for our sample firms is .17 which is also approximately consistent with a random walk. The assumption is not critical to most of our results (the major exception is that earnings is a random walk). Even if sales follow an autoregressive process in first differences, accruals still offset the negative serial correlation in operating cash flow changes induced by inventory and working capital financing policies. This produces earnings that are better forecasts of future operating cash flows than current operating cash flows and moves earnings changes closer to being serially uncorrelated. When our analysis is repeated assuming an autoregressive process for sales, the *signs* of the predicted relations and correlations (other than earnings changes) and the results are essentially unchanged.

The relation between sales and cash flow from sales is not one-to-one because sales are made on credit. Specifically, we assume that proportion α of the firm's sales remains

uncollected at the end of the period so that accounts receivable for period t , AR_t , is as follows:

$$AR_t = \alpha S_t \quad (2)$$

The accounts receivable accrual incorporates future cash flow forecasts (collections of accounts receivable) into earnings.

In this section, we assume all expenses vary with sales so the expense for period t is $(1 - \pi)S_t$, where π is the net profit margin on sales and earnings (E_t) are πS_t . In section 5 we modify the expense assumption to allow for fixed expenses. Inventory policies introduce differences between expense and cash outflows and hence between earnings and cash flows. Inventory is a case where future cash proceeds are not verifiable and so are not included in earnings. Instead if it is likely cost will be recovered, the cost is capitalized and excluded from expense. In essence, the inventory cost is the forecast of the future cash flows that will be obtained from inventory. We assume inventory is valued at full cost.

Following Bernard and Stober (1989), we assume a firm's inventory at the end of period t consists of a target level and a deviation from that target. Target inventory is a constant fraction, γ_1 , of next period's forecasted cost of sales. Since we assume sales follow a random walk, target inventory is $\gamma_1(1 - \pi)S_t$, where $\gamma_1 > 0$.⁴ Target inventory is maintained if a firm increases its inventory in response to sales changes by $\gamma_1(1 - \pi)\Delta S_t$ where $\Delta S_t = S_t - S_{t-1} = \varepsilon_t$. Actual inventory deviates from the target because actual sales differ from forecasts and there is an inventory build up or liquidation. The deviation is given by $\gamma_2\gamma_1(1 - \pi)[S_t - E_{t-1}(S_t)] = \gamma_2\gamma_1(1 - \pi)\varepsilon_t$, where γ_2 is a constant that captures the speed with which a firm adjusts its inventory to the target level. If γ_2 is 0 the firm does not deviate from the target, while if $\gamma_2 = 1$, the firm makes no inventory adjustment. Inventory for period t , INV_t , is then:

$$INV_t = \gamma_1(1 - \pi)S_t - \gamma_2\gamma_1(1 - \pi)\varepsilon_t \quad (3)$$

⁴ Bernard and Stober's (1989) purpose in developing the inventory model is to obtain a more accurate proxy for the market's forecast of cash flows and earnings so that more powerful tests of their correlations with stocks returns can be performed. Our focus is quite different. We are interested in the role of accruals in reducing the dependence in successive cash flow changes in producing earnings.

The first term in equation (3) is the target inventory and the second term is the extent to which the firm fails to reach that target inventory.

The credit terms for purchases are a third factor causing a difference between earnings and cash flows. Purchases for period t , P_t , are:

$$P_t = (1 - \pi)S_t + \gamma_1(1 - \pi)\epsilon_t - \gamma_1\gamma_2(1 - \pi)\Delta\epsilon_t \quad (4)$$

If a firm is able to purchase all its inputs just in time so inventory is zero ($\gamma_1 = 0$), purchases for the period, P_t , just equals expense for the period, $(1 - \pi)S_t$. The second term in equation (4) consists of the purchases necessary to adjust inventory for the change in target inventory, $\gamma_1(1 - \pi)\epsilon_t$. The third term is the purchases that represent the deviation from target inventory, $-\gamma_2\gamma_1(1 - \pi)\epsilon_t$. Since purchases are on credit, like sales, the cash flow associated with purchases differs from P_t . We assume proportion β of the firm's purchases remains unpaid at the end of the period so that accounts payable for period t , AP_t , is as follows:

$$\begin{aligned} AP_t &= \beta P_t \\ &= \beta[(1 - \pi)S_t + \gamma_1(1 - \pi)\epsilon_t - \gamma_1\gamma_2(1 - \pi)\Delta\epsilon_t] \end{aligned} \quad (5)$$

The accounts payable accrual is a forecast of future cash outflows.

Combining the cash inflows from sales and outflows for purchases, the (net operating) cash flow for period t (CF_t) is:

$$\begin{aligned} CF_t &= (1 - \alpha)S_t + \alpha S_{t-1} - (1 - \beta)[(1 - \pi)S_t + \gamma_1(1 - \pi)\epsilon_t - \gamma_1\gamma_2(1 - \pi)\Delta\epsilon_t] \\ &\quad - \beta[(1 - \pi)S_{t-1} + \gamma_1(1 - \pi)\epsilon_{t-1} - \gamma_1\gamma_2(1 - \pi)\Delta\epsilon_{t-1}] \\ &= \pi S_t - [\alpha + (1 - \pi)\gamma_1 - \beta(1 - \pi)]\epsilon_t + \gamma_1(1 - \pi)[\beta + \gamma_2(1 - \beta)]\Delta\epsilon_t + \beta\gamma_1\gamma_2(1 - \pi)\Delta\epsilon_{t-1} \end{aligned} \quad (6)$$

The first term in expression (6), πS_t , is the firm's earnings for the period (E_t) and so the remaining terms are accruals.

Rearranging equation (6) to show the earnings calculation is helpful:

$$E_t = CF_t + [\alpha + (1 - \pi)\gamma_1 - \beta(1 - \pi)]\epsilon_t - \gamma_1(1 - \pi)[\beta + \gamma_2(1 - \beta)]\Delta\epsilon_t - \beta\gamma_1\gamma_2(1 - \pi)\Delta\epsilon_{t-1} \quad (7)$$

If there are no accruals (sales and purchases are cash so $\alpha = \beta = 0$, and no inventory so $\gamma_1 = 0$), all the terms other than the first in equation (7) are zero and the earnings and cash flows for the period are equal. The second, third and fourth terms express the period's accruals

as a function of the current shock to sales and differences in current and lagged sales shocks. The second term in expression (7) is the temporary cash flow due to the change in expected long-term working capital (i.e., the working capital once all the cash flows due to lagged adjustment of inventory and credit terms have occurred). It is the shock to sales for the period, ϵ_t , multiplied by a measure of the firm's expected long-term operating cash cycle expressed as a fraction of a year, $[\alpha + (1-\pi)\gamma_1 - \beta(1-\pi)]$, which we denote by δ .⁵ The third and fourth terms are temporary cash flows due to the lagged adjustment of inventory and credit terms. Full adjustment takes two periods because part of the purchases representing the adjustment to the target inventory occurs in the period following the sales shock and in turn part of the payment for those purchases occurs another period later.

Empirically, the coefficients of the differences in sales shocks in the third and fourth terms in equation (6) are close to zero and do not affect relative predictive ability or the predicted signs of the correlations. Given that, we ignore the two terms in providing the intuition for our results (see later). For convenience, θ_1 and θ_2 are used to represent the two coefficients:

$$CF_t = \pi S_t - \delta \epsilon_t + \theta_1 \Delta \epsilon_t + \theta_2 \Delta \epsilon_{t-1} \quad (8)$$

and:

$$E_t = CF_t + \delta \epsilon_t - \theta_1 \Delta \epsilon_t - \theta_2 \Delta \epsilon_{t-1} \quad (9)$$

Current earnings is current cash flows adjusted by accruals. Since the accruals represent all the temporary cash flows, current earnings is the permanent cash flow.

⁵The operating cash cycle expressed as a fraction of a year is the fraction of annual sales in receivables plus the fraction of annual cost of goods sold in inventory minus the fraction of annual cost of goods sold in payables (see for example, Ross, Westerfield and Jaffe, 1993, p. 756). Averages of receivables, inventory and payables and annual amounts of sales and cost of goods sold are usually used in the calculation. Our measure, δ , differs from the typical calculation in three ways: first it uses the expected year-end values of receivables, inventory and payables rather than averages for the year; second receivables are expressed as fractions of expected annual sales rather than actual annual sales; and third inventories and payables are expressed as fractions of expected annual sales rather than of annual cost of goods sold. The fraction of expected sales in expected receivables for year t is then $\frac{\alpha S_{t-1}}{S_{t-1}} = \alpha$. The expected inventory at the end of year t is $\gamma_1(1-\pi)S_{t-1}$ and as a fraction of expected sales is $\frac{\gamma_1(1-\pi)S_{t-1}}{S_{t-1}} = \gamma_1(1-\pi)$. Expected accounts payable as a fraction of expected sales is $\frac{\beta(1-\pi)S_{t-1}}{S_{t-1}} = \beta(1-\pi)$.

3.2 An explanation for the negative serial correlation in operating cash flow changes

In the previous section we noted that in our model if the firm did not engage in credit transactions and carried no inventory, current cash flows would equal current earnings and, like earnings changes, cash flow changes would be serially uncorrelated. Hence, in our model any negative serial correlation in cash flow changes must be due to the firm's working capital policies.

To demonstrate the above proposition note from equation (8) that the change in cash flow for period t , ΔCF_t , is:

$$\Delta CF_t = \pi \varepsilon_t - \delta(\varepsilon_t - \varepsilon_{t-1}) + \theta_1 \Delta \varepsilon_t + (\theta_2 - \theta_1) \Delta \varepsilon_{t-1} - \theta_2 \Delta \varepsilon_{t-2} \quad (10)$$

Given θ_1 and θ_2 are close to zero and ε_t is serially uncorrelated, it is the second term in expression (14) that is primarily responsible for the serial correlation in cash flow changes. The full equation for the predicted serial correlation in cash flow changes is given in table 1 and the empirical work is conducted using that equation. To gain intuition as to the behavior of the serial correlation in cash flow changes, however, assume $\theta_1 = \theta_2 = 0$ so that the second term in equation (10) is completely responsible for the serial correlation. Formally, the serial correlation in changes in cash flows is then (table 1 also reports all the correlations assuming $\theta_1 = \theta_2 = 0$ to easily see the signs of the predicted correlations):

$$\rho_{\Delta CF_t, \Delta CF_{t-1}} = \frac{\delta(\pi - \delta)}{(\pi^2 + 2\delta^2 - 2\delta\pi)} \quad (11)$$

The sign of this serial correlation is a function of the relative magnitudes of the profit margin and the expected operating cash cycle expressed as a fraction of the year. Since δ and π are expected to be positive and the denominator in equation (11), $(\pi^2 + 2\delta^2 - 2\delta\pi)$, is always positive, it is easy to see that the serial correlation in cash flow changes is negative so long as $\pi < \delta$, i.e., the net margin is less than the operating cash cycle. Descriptive statistics reported in section 4 show that $\pi < \delta$ is the case for the overwhelming majority of firms. The partial derivative of $\rho_{\Delta CF_t, \Delta CF_{t-1}}$ with respect to δ , $(\pi - 2\delta)\pi/(\pi^2 + 2\delta^2 - 2\delta\pi)$, is negative when $\pi < 2\delta$. Thus, holding the profit margin constant, the longer the expected operating cash cycle, the more negative the serial correlation in cash flow changes. For a very few firms the operating cash cycle is less than the profit margin and

the expected serial correlation is positive. But, for most firms the expected operating cash cycle is larger than the profit margin and the expected serial correlation is negative.

The serial correlation pattern is the net result of two effects. The first is the spreading of the collection of the net cash generated by the profit on the current period sales shock across adjacent periods which, absent any difference in the timing of cash outlays and inflows, leads to positive serial correlation in cash flow changes. The second effect is due to differences in the timing of the cash outlays and inflows generated by the shock which, absent the first effect, leads to negative serial correlation in cash flow changes.

To see the first effect, assume there is credit ($0 < \alpha$) but there is no difference in the timing of cash receipts and payments (the credit terms on sales and purchases are the same so that $\alpha = \beta$) and the firm buys just in time so inventory is zero and $\gamma_1 = 0$. Then the operating cash cycle (δ) is $\alpha\pi$ and relatively short. Since by assumption $0 < \alpha \leq 1$, the numerator of equation (11), $\delta(\pi - \delta)$, will be positive, and the denominator of equation (11) is positive, so the correlation is positive. Thus, when the firm experiences a positive shock to sales (ϵ_t), the firm receives cash flows of proportion $(1-\alpha)$ of the profit on the shock ($\pi\epsilon_t$) in the current period and proportion α next period. Both periods' cash flows rise with the shock, so the correlation of the cash flow changes is positive.

To see the second effect, assume there is no profit, $\pi = 0$ in equation (11), and there is no spreading of the cash represented by net profit across periods. Only the difference in timing of cash outlays and inflows (the operating cash cycle) effect is present. The serial correlation in cash flow changes then is negative, $-\delta^2/2\delta^2 = -0.5$.

As the operating cash cycle increases from $\alpha\pi$ (holding the profit margin, π , constant), the timing effect comes into play; α exceeds β (the usual case), inventories become positive ($\gamma_1 > 0$) and purchases tend to be paid before revenues are collected. The shock starts to cause outflows in the current period and cash inflows in the next period, which by itself would induce negative correlation. After $\delta > \pi$, this timing effect dominates the spreading of the profit across periods and the overall correlation is negative. In most firms, the timing effect dominates the profit spread effect. In our sample using annual data, the mean estimates of δ and π are 0.32 and 0.05 respectively. So, the negative serial

correlation in operating cash flow changes is generated by most firms being long (having a positive net investment) in working capital.

3.3 Relative abilities of earnings and current operating cash flows to predict future operating cash flows

The best forecast of one-period-ahead future operating cash flows (forecast of cash flows in period $t+1$ made at time t) under the simple model is (from equation 8)

$$E(CF_{t+1}) = \pi S_t + (\theta_2 - \theta_1)\varepsilon_t - \theta_2\varepsilon_{t-1} \quad (12)$$

Given θ_1 and θ_2 are close to zero the best forecast is close to the current earnings ($E_t = \pi S_t$). The best period forecast of two period ahead future cash flows is also close to current earnings ($\pi S_t - \theta_2\varepsilon_t$) and the best forecast for cash flows more than two periods in the future is current earnings (πS_t). So earnings is the best forecast of permanent cash flows. This is not surprising since we saw in section 3.1 that accruals adjust cash flows for temporary cash flows due to the outlay for the expected increase in long-term working capital and the difference in timing of cash outflows for purchases and cash inflows from sales. In essence, earnings undo the negative serial correlation in cash flow changes.

The forecast error variance for the best one period ahead forecast [$\sigma^2(FE_{t+1})$] is

$$\sigma^2(FE_{t+1}) = (\pi - \delta + \theta_1)^2\sigma^2. \quad (13)$$

And, the forecast error variances for the best two period and three period ahead forecasts are $[(\pi - \delta + \theta_1)^2 + (\pi - \theta_1 + \theta_2)^2]\sigma^2$ and $[(\pi - \delta + \theta_1)^2 + (\pi - \theta_1 + \theta_2)^2 + (\pi - \theta_2)^2]\sigma^2$, respectively.

Using current earnings to forecast future operating cash flows one-period-ahead generates a forecast error variance of

$$\sigma^2(FE_{t+1}) = (\pi - \delta + \theta_1)^2\sigma^2 + [(\theta_2 - \theta_1)^2 + \theta_2^2]\sigma^2 \quad (14)$$

Which is the same as the forecast error variance for the best one period ahead forecast except for the second term. As we have noted θ_2 and θ_1 are both close to zero so the second term in equation (14) is close to zero and the forecast error variance using current earnings is very close to the forecast error variance using the best forecast. The forecast error variance for the two period ahead forecast using earnings is $[(\pi - \delta + \theta_1)^2 + (\pi - \theta_1 + \theta_2)^2]\sigma^2 + \theta_2^2\sigma^2$ which differs from the best forecast by the last term only. Since the best

forecast for cash flows three periods ahead is current earnings, the error variance for the forecast using earnings is the same as that for the best forecast, $[(\pi - \delta + \theta_1)^2 + (\pi - \theta_1 + \theta_2)^2 + (\pi - \theta_2)^2]\sigma^2$.

Using current operating cash flows to forecast future operating cash flows one-period-ahead produces a larger forecast error than the forecast using earnings. The forecast error using cash flows is the change in cash flows and the forecast error variance is:

$$\sigma^2(\text{FE}_{t+1}) = (\pi - \delta + \theta_1)^2\sigma^2 + [(\delta + \theta_2 - 2\theta_1)^2 + (\theta_1 - 2\theta_2)^2 + \theta_2^2]\sigma^2 \quad (15)$$

The additional terms in the forecast error variance using cash flows [equation (15)] vis-a-vis the best model's forecast error variance [equation (12)] include δ which unlike θ_2 and θ_1 is not close to zero. If $\theta_1 = \theta_2 = 0$ the forecast error variance is the same for the best and the earnings forecasts $[(\pi - \delta)^2\sigma^2]$ but higher for the current cash flow forecast by $\delta^2\sigma^2$. In fact this result holds for all longer forecast horizons as well. The reason is that the current cash flows include the one time cash flow for the change in long-term working capital $\delta\epsilon_t$ due to the current sales shock.

The preceding result is the basis for two hypotheses tested in this paper

- (1) Current earnings are more accurate forecasts of future operating cash flows than are current operating cash flows; and
- (2) The longer the firm's expected operating cash cycle (δ) the larger the difference in forecasting accuracy between current earnings and current operating cash flows.

3.4 Other time series properties of earnings, operating cash flows and accruals

Serial correlation in accruals changes. The only accruals in the simple model are accounts receivable, ΔAR_t , plus the change in inventory for period t , ΔInv_t , minus the change in accounts payable for period t , ΔAP_t :

$$\begin{aligned}
A_t &= \Delta AR_t + \Delta Inv_t - \Delta AP_t \\
&= \alpha \varepsilon_t + [\gamma_1(1-\pi)\varepsilon_t - \gamma_2\gamma_1(1-\pi)\Delta\varepsilon_t] - [\beta((1-\pi)\varepsilon_t + \gamma_1(1-\pi)\Delta\varepsilon_t \\
&\quad - \gamma_1\gamma_2(1-\pi)\Delta\varepsilon_t + \gamma_1\gamma_2(1-\pi)\Delta\varepsilon_{t-1})] \\
&= [\alpha + \gamma_1(1-\pi) - \beta(1-\pi)]\varepsilon_t - \gamma_1(1-\pi)[\beta + \gamma_2(1-\beta)]\Delta\varepsilon_t - \beta\gamma_1\gamma_2(1-\pi)\Delta\varepsilon_{t-1} \\
&= \delta\varepsilon_t - \gamma_1(1-\pi)[\beta + \gamma_2(1-\beta)]\Delta\varepsilon_t - \beta\gamma_1\gamma_2(1-\pi)\Delta\varepsilon_{t-1}
\end{aligned}$$

Substituting θ_1 and θ_2 ,

$$A_t = \delta\varepsilon_t - \theta_1\Delta\varepsilon_t - \theta_2\Delta\varepsilon_{t-1} \quad (16)$$

Accruals in equation (16) can be re-written as

$$\begin{aligned}
A_t &= [\alpha S_t + \gamma_1(1-\pi)S_t - \gamma_2\gamma_1(1-\pi)\varepsilon_t - \beta P_t] - \\
&\quad [\alpha S_{t-1} + \gamma_1(1-\pi)S_{t-1} - \gamma_2\gamma_1(1-\pi)\varepsilon_{t-1} - \beta P_{t-1}]
\end{aligned} \quad (17)$$

Equation (17) decomposes accruals into two components. The first component accrues expected future cash flows from current sales, inventories and purchases into current earnings, whereas the second component reduces current earnings for the cash flow from past sales, inventories and purchase activity that was recognized in previous earnings through previous accruals.⁶ Thus, the accrual process, like the valuation capitalization process, captures future cash flow changes implied by the current cash flow changes.

Using equation (16), the change in accruals for period t , ΔA_t , is:

$$\Delta A_t = (\delta - \theta_1)\Delta\varepsilon_t - (\theta_2 - \theta_1)\Delta\varepsilon_{t-1} + \theta_2\Delta\varepsilon_{t-2} \quad (18)$$

The full equation for the serial correlation in accrual changes is given in table 1 and the empirical work is conducted using that equation. To gain intuition as to the behavior of the serial correlation in accrual changes again assume $\theta_1 = \theta_2 = 0$. Formally, the serial correlation in accrual changes is then:

$$\begin{aligned}
\rho_{\Delta A_t \Delta A_{t-1}} &= \frac{-\delta^2\sigma^2}{2\delta^2\sigma^2} \\
&= -0.5
\end{aligned} \quad (19)$$

which is close to the average estimate of -0.44 obtained by Dechow (1994, table 2). Note with $\theta_1 = \theta_2 = 0$ the serial correlation in accrual changes is independent of the α , β , and π

⁶Note though that the future cash flow from inventory is assumed equal to cost and not to selling price.

parameters because, as seen from equation (16), with $\theta_1 = \theta_2 = 0$, accruals themselves follow a mean zero, white noise time series process and serial correlation in the first difference of a white noise series is always -0.5.

Comparison of equation (18) for change in accruals with equation (10) for change in cash flows reveals that the $(\delta - \theta_1)\Delta\epsilon_t - (\theta_2 - \theta_1)\Delta\epsilon_{t-1} + \theta_2\Delta\epsilon_{t-2}$ term is common to both changes in accruals and cash flows, but with opposite signs. Therefore, as noted previously, accruals are expected to undo the negative serial correlation in cash flows to produce serially uncorrelated earnings changes. Because historical-cost earnings measurement rules do not recognize all the future cash flows, in practice, we expect accruals empirically to reduce the serial correlation in cash flows, but not eliminate it.

Serial correlation in earnings changes. Since all expenses in our simple model are variable, earnings like sales follows a random walk:

$$E_t = E_{t-1} + \pi\epsilon_t \quad (20)$$

and the serial correlation in earnings changes is zero because ϵ_t is serially uncorrelated. This prediction is, of course, dependent on the assumption that sales follow a random walk. For example, if sales followed a simple autoregressive process, with the variable expense assumption earnings would follow a similar process.

The preceding analysis shows that a very simple model of the firm that assumes sales follow a random walk and allows only for accounts receivable, accounts payable and inventory accruals can generate the basic time series properties observed for operating cash flows, earnings, and accruals. As mentioned in the introduction, one reason for accountants' interest in the properties of accruals, earnings, and cash flows is to further our understanding of why accruals make earnings a better measure of firm performance than cash flows. That is, why is earnings, which is the sum of the cash flow and accruals, better than cash flow itself in forecasting future cash flow changes? Dechow's (1994) answer is that accrual changes and cash flow changes are negatively cross-correlated. This result is also produced by our simple model.

Contemporaneous correlation between accrual and operating cash flow changes. The contemporaneous correlation between accrual changes and cash flow changes is derived using expressions (18) and (10) and is given in table 1. Intuition for the sign of the covariance is obtained by again assuming $\theta_1 = \theta_2 = 0$. The covariance is

$$\begin{aligned}
\text{Cov}[\Delta A_t, \Delta CF_t] &= \text{Cov}[\delta(\varepsilon_t - \varepsilon_{t-1}), \pi\varepsilon_t - \delta(\varepsilon_t - \varepsilon_{t-1})] \\
&= \delta(\pi - 2\delta)\sigma^2
\end{aligned} \tag{21}$$

The correlation coefficient is

$$\begin{aligned}
\rho_{\Delta A_t, \Delta CF_t} &= \frac{\delta(\pi - 2\delta)\sigma^2}{[2\delta^2(\pi^2 - 2\delta\pi + 2\delta^2)]^{0.5}\sigma^2} \\
&= (\pi - 2\delta)/[\pi^2 - 2\delta\pi + 2\delta^2]^{0.5}
\end{aligned} \tag{22}$$

which is negative so long as the profit margin, π , is less than twice δ . For most firms, $\rho_{\Delta A_t, \Delta CF_t}$ is expected to be negative because the profit margin, π , is likely to be considerably smaller than the expected operating cash cycle expressed as a fraction of a year, δ , for the average firm.

Contemporaneous correlation between earnings and operating cash flow changes. The contemporaneous correlation between earnings and operating cash flow changes is obtained from expressions (20) and (10) and is reported in table 1. Again intuition for the sign is obtained by assuming $\theta_1 = \theta_2 = 0$. The covariance is

$$\begin{aligned}
\text{Cov}(\Delta CF_t, \Delta E_t) &= \text{Cov}[(\pi - \delta)\varepsilon_t + \delta\varepsilon_{t-1}, \pi\varepsilon_t] \\
&= \text{Cov}[(\pi - \delta)\varepsilon_t, \pi\varepsilon_t] \\
&= \pi(\pi - \delta)\sigma^2
\end{aligned} \tag{23}$$

The correlation coefficient is

$$\begin{aligned}
\rho_{\Delta CF_t, \Delta E_t} &= \frac{\pi(\pi - \delta)\sigma^2}{[\pi^2(\pi^2 + 2\delta^2 - 2\delta\pi)]^{0.5}\sigma^2} \\
&= (\pi - \delta)/(\pi^2 + 2\delta^2 - 2\delta\pi)^{0.5}
\end{aligned} \tag{24}$$

which is negative so long as the profit margin, π , is less than δ , the operating cash cycle. We expect this to be true for the average firm. We discuss the correlation in more detail in section 5 of the paper.

Correlation between current accrual and earnings changes and future operating cash flow changes. Working capital accruals capturing future cash flows should produce a positive cross-serial correlation between both current accrual and earnings

changes and future cash flow changes. Assuming $\theta_1 = \theta_2 = 0$, the correlation between accrual changes of period t and cash flow changes of period $t+1$ is

$$\rho \Delta A_t \Delta CF_{t+1} = \delta / [2(\pi^2 - 2\delta\pi + 2\delta^2)]^{0.5}. \quad (25)$$

and the correlation between earnings changes of period t and cash flow changes of period $t+1$ is

$$\rho \Delta E_t \Delta CF_{t+1} = \delta / [(\pi^2 - 2\delta\pi + 2\delta^2)]^{0.5}. \quad (26)$$

Since $\delta > 0$ for most firms both formulas in equations (25) and (26) suggest positive correlation. And, as implied by the analysis in 3.3 both correlation formulas suggest the forecasting abilities of accruals and earnings are increasing in the cash operating cycle, δ .

[Table 1]

3.5 Summary

A simple model of earnings, operating cash flows, and accruals developed in this section generates an explanation for the negative serial correlation in operating cash flow changes. Increases (decreases) in sales generate contemporaneous outlays (inflows) for working capital increases (decreases) that are followed in the next period by cash inflows (outflows). The result is negative serial correlation in cash flow changes. Accruals exclude the contemporaneous one-time outflows for working capital from the current period's earnings and incorporate forecasts of permanent future cash inflows. This causes earnings to be a relatively better predictor of future cash flows than is current cash flows. It also generates negative serial correlation in accrual changes that offsets the negative serial correlation in operating cash flow changes. If sales follow a random walk and all expenses are variable, earnings also follow a random walk.

4. Tests of relative forecast ability and correlation predictions

The objective of this section is to:

- i) compare the relative abilities of earnings and operating cash flows to predict future operating cash flows;
- ii) compare the simple model's average predicted serial- and cross-correlations in changes in operating cash flows, earnings, and accruals with the average actual correlations; and

- iii) investigate whether the predicted correlations for firms and portfolios of firms are cross-sectionally related to the actual correlations for those firms and portfolios of firms

We directly test our contracting arguments' and simple model's that earnings by itself is a better forecast of future operating cash flows than current operating cash flows by itself. The test uses earnings and cash flows individually as forecasts of one- to three-year-ahead operating cash flows. Since this test does not require estimation of any parameters, all forecasts are out of sample. We also test the proposition that the forecasting superiority of current earnings relative to current operating cash flows increases with the operating cash cycle, δ .

To compare predicted and actual correlations and investigate the cross-sectional relation between the two, predicted numerical values of various correlations are calculated using estimated values of the model parameters, α , β , γ_1 , γ_2 , δ , θ_1 , θ_2 , and π . These are estimated for a sample of 1,337 New York and American Stock Exchange firms. The parameter values are based on each firm's average investments in receivables, inventories, and payables as a fraction of annual sales and net profit margin (details are provided in the next subsection).

We compare the predicted values with actual correlations for the sample firms and investigate the cross-sectional relation between them to assess the extent to which the simple model described in the previous section fits the data. First, we report the average values of the predicted serial- and cross-correlations among earnings changes, operating cash flow changes and accrual changes. Comparison of average values of predicted and actual correlations assumes homogeneity of the correlations across all firms. However, we also report the average, median, and selected fractiles of the distribution of serial- and cross-correlations that are estimated using firm-specific time series of actual data on changes in cash flows, earnings, and accruals. The areas of disagreement between the predicted and actual average values motivate us to modify the simple model. The modifications to the simple model and associated data analysis are provided in sections 5 and 6.

To investigate the cross-sectional relation between predicted and actual correlations we cross-sectionally correlate predicted and actual correlations for firms and portfolios of firm. A significant positive correlation between the predicted and actual correlations implies the model is helpful in explaining cross-sectional variation in the time series properties of cash flows, accruals and earnings.

Section 4.1 offers a discussion of data and descriptive statistics. The tests of the relative forecast abilities of cash flows and earnings are presented in section 4.2. Section 4.3 compares the average predicted and actual correlations and section 4.4 reports the cross-sectional correlation between predicted and actual correlations.

4.1 Data and descriptive statistics

Financial data for sample firms are obtained from the Compustat Annual Industrial and Annual Research tapes. We use *annual* financial data because at this point in the development of the literature, we do not think the use of quarterly data is cost-effective. The cost of using quarterly data is that it is available for a shorter time period than annual data and it makes both analytics and empirics considerably more complicated introducing considerable measurement error into the empirical analysis. Seasonality in quarterly data requires the analytics be modified or the seasonality removed from the data prior to testing. Either way considerable measurement error is likely to be introduced into the empirical analysis. In addition, there is evidence that the accrual process differs between quarters for other than seasonal reasons. Collins, Hopwood and McKeown (1984), Kross and Schroeder (1990) and Salamon and Stober (1994) report evidence consistent with the fourth quarter reports reflecting the correction of errors in the previous three quarterly reports. Hayn and Watts (1997) find that more transitory earnings items and more losses are reported in the fourth quarter. This evidence is consistent with an accounting process that concentrates on an annual horizon. Modeling this process across quarters, like modeling seasonality, is likely to introduce considerable error into the empirical analysis.

The benefit from using quarterly data is that, ignoring the analytical and empirical issues associated with quarterly data, the shorter the earnings measurement interval, the more likely we will observe the phenomena we expect. The shorter the period, the larger accruals are relative to cash flows (the larger the end-point problem) which translates into greater expected differences in the relative forecast abilities of earnings and operating cash flows and in the time series properties of earnings, accruals and operating cash flows. Our 'a priori' assessment is that this benefit is more than offset by the difficulties of modeling and estimating the intra-year accounting process, a topic which by itself is more than enough for another paper.

We include in our sample firms for which at least ten annual earnings, accruals, operating cash flow, and sales observations in first differences (i.e., 11 years of data) are available. The earliest year for which data are available is 1963 and the latest is 1992. To avoid undue influence of extreme observations, we exclude 1% of the observations with the largest and smallest values of earnings, accruals, cash flows, and sales. Since we use

first-difference time series of all the variables, deletion of 1% extreme observations results in a loss of twice as many observations as applying the filter to levels. The final sample consists of 22,776 first-difference observations on 1,337 firms. The 11 years data requirement means the sample consists of surviving firms. Caution should therefore be exercised in generalizing the results from this study. One potential consequence of the survivor bias in our sample is that the estimated correlations might be positively biased. However, we do not expect this bias to taint our cross-sectional analysis.

We use per share values, adjusted for changes in share capital and splits etc., of the following variables: E = earnings before extraordinary items and discontinued operations; CF = cash flow from operations, which is calculated as operating income before depreciation minus interest minus taxes minus changes in noncash working capital⁷; A = operating accruals, which are earnings before extraordinary items and discontinued operations minus cash flow from operations, or E - CF. Since some of the model parameter values are calculated as a fraction of sales, we also describe sales per share data.

Operating accruals include accruals not incorporated in the simple model, in particular depreciation accruals. Empirically then the accruals variable is inconsistent with the model. Two considerations led us to estimate the model using operating accruals in spite of the inconsistency. First, the simple model is developed to provide intuitive insights into the relations between accruals, earnings, and cash flows. Empirical tests using accruals that go beyond the simple working capital accruals is an attempt to see if the simple model suffices in explaining observed correlations among cash flows, accruals, and earnings. Second, empirically depreciation accruals have very little effect on the time series properties of first differences in accruals.⁸ We correlate each firm's time series of annual changes in accruals inclusive of depreciation with accruals exclusive of depreciation changes. The average correlation across all the firms is 0.98, the median is 0.995, and the 5th percentile is 0.89. Depreciation accruals therefore have virtually no effect on the time series properties of accrual changes and their inclusion or exclusion have little effect on the empirical results reported in the paper.

Table 2 provides descriptive statistics on earnings, cash flows, accruals, and sales, first differences in these variables, and variance of first differences in each variable. For each variable, we report the mean, standard deviation, minimum, 25th percentile, median,

⁷An alternative measure of operating cash flows would be the cash flow that has been required by SFAS 95 to be reported in the statement of cash flows since 1987. We do not use the SFAS 95 measure because that would restrict our analysis to a less than 10 year period, a period too short to perform time-series analysis.

⁸ Depreciation does have a significant effect on the cross-correlations of the variables' levels.

75th percentile, and maximum value. These are calculated using 1,337 firm-specific average values for each variable, except in the case of variances.

[Table 2]

Average earnings per share is \$1.13. Because earnings contain large non-cash expenses like depreciation and amortization, we expect operating cash flow per share to exceed earnings per share. The difference between the two is given by the average accruals per share, which is \$-0.50 for our sample. Average variance of the change in accruals and cash flows is considerably higher than that of earnings. This is consistent with accruals smoothing out cash flow fluctuations, i.e., the two are negatively contemporaneously correlated.

We also estimate, but do not report in the table, the first-order serial correlation in sales changes. It is 0.17, with a t-statistic of 21.1.⁹ It is well known that there is a small-sample bias in the estimated values of serial correlations (Kendall, 1954). Since a relatively small number of annual observations of financial data are available, the negative bias in the serial correlation estimates [equal to $-1/(T - 1)$, where T is the number of time series observations] can be substantial (e.g., Ball and Watts, 1972, and Jacob and Lys, 1995). The serial correlations reported in this study are adjusted for the bias. The small degree of positive serial correlation in sales changes suggests that a random walk in sales is an approximate description of the data.

Table 3 provides descriptive statistics on the parameter values estimated for the sample firms. Profit margin on sales, π , is the ratio of earnings (before extraordinary items and discontinued operations) to sales, averaged across the number years for which data are available for a firm. To calculate $\delta = [\alpha + (1 - \pi)\gamma_1 - \beta(1 - \pi)]$, $\theta_1 = \gamma_1(1 - \pi)[\beta + \gamma_2(1 - \beta)]$, and $\theta_2 = \beta\gamma_1\gamma_2(1 - \pi)$, we define:

$$\alpha_t = [(AR_t + AR_{t-1})/2Sales_t],$$

$$\beta_t = [(AP_t + AP_{t-1})/(2Sales_t(1 - \pi))],$$

$$\pi_t = E_t/Sales_t,$$

$$\gamma_1 = \text{target inventory as a fraction of forecasted cost of sales,}$$

$$\gamma_2 = \text{speed with which inventory adjusts to the target level,}$$

⁹The t-statistic is calculated assuming the observations are cross-sectionally uncorrelated. Since financial data are positively cross-correlated, the t-statistic is likely to be overstated.

where AR_t is accounts receivables, and AP_t is accounts payable, all at the end of year t . The inventory parameters, γ_1 and γ_2 , are estimated from firm-specific time series regressions of inventory on sales and sales change (see the appendix for details). For each firm, δ , θ_1 , and θ_2 are the time-series averages of their annual values.

The average profit margin for the sample firms in table 3 is 4.95%. Because of systematic (industry) differences across the sample firms in asset and inventory turnover ratios and because the sample consists of *ex post* winners and losers, there is considerable dispersion in profitability of the firms. The inter-quartile range, however, is less than 4% (i.e., from 2.60% to 6.37%). The target operating cash cycle, δ , averages 0.32 for the sample firms. This means a typical firm's cash cycle is approximately 116 days. Most of this is due to investments in accounts receivables and inventories, which is seen from the average values of α of 0.30 and γ_1 of 0.16. Average values of θ_1 and θ_2 are close to zero, but there is considerable dispersion in the estimates of θ_1 across the sample firms.

[Table 3]

4.2 Cash flow prediction tests

In this section we directly test the predictive ability of earnings and operating cash flows with respect to future operating cash flows. We partition the data according to the firms' operating cash cycle, which corresponds to δ in the model.¹⁰ We expect earnings' superiority over cash flows to increase in the operating cycle.

Table 4 reports cross-sectional means of firm-specific standard deviations of forecast errors defined as the difference between actual one-, two-, and three-year-ahead operating cash flows minus current operating cash flows or current earnings. Since earnings for our sample are calculated after deducting investment costs (i.e., depreciation), earnings are a downward biased estimate of future operating cash flows. However, since the time series of depreciation expense is relatively smooth, estimated standard deviations are relatively unaffected by the bias. Not surprisingly, we obtain similar results from an analysis using earnings before depreciation as a forecast of future cash flows.

For the entire sample, the mean standard deviation of one-year-ahead forecast errors using current operating cash flows as the forecast is \$1.89 per share, compared to \$1.60

¹⁰ The estimation of δ and the forecast tests are performed using data for the same time period. To make the test truly out of sample, we also perform the analysis estimating δ using pre-1983 data for each firm

per share using earnings to forecast cash flows. The mean pairwise difference of \$0.29 per share is statistically significant (t-statistic = 17.87). The test, however, makes a tenuous assumption of cross-sectional independence, and thus the significance level should be interpreted cautiously. Two- and three-year-ahead forecast errors using earnings are also less variable than those using operating cash flows. Cash flow based forecast errors' variability rises from \$1.89 per share at the one year forecast horizon to \$2.10 per share at the three-year forecast horizon. By contrast, earnings-based forecast errors exhibit only a modest increase from \$1.60 to \$1.65 per share.

[Table 4]

The results for quartile sub-samples (labeled Q1-Q4 in table 4) formed by ranking firms according to their cash operating cycles are generally consistent with the relative forecast accuracy being a function of that cycle. The mean pairwise difference between cash-flow-based and earnings-based forecast error variability is significantly greater (at the .05 level) for quartile 4 than quartile 1 at all three forecast horizons. The mean pairwise difference increases monotonically at two- and three-year-ahead horizons and only the mean pairwise difference for Q4 violates the monotonic pattern at one-year-ahead horizon. Given the number of possible comparisons of differences, we note that the standard error for the differences is such that a difference of approximately .06 is required for significance and leave the reader to assess the significance of the differences of interest. For example, for the one-year-ahead horizon, the difference for Q2 is only .04 greater than the difference for Q1 and so is not significantly larger at the .05 level. The difference for Q3 on the other hand is .11 larger than (and so significantly larger than) that for Q1.

4.3 Comparison of average predicted and actual correlations

Table 5 summarizes predicted and actual correlations between cash flow changes, accrual changes, and earnings changes for an average firm. The first column of table 5 reports the variables between which the correlation is being examined. For each pair of variables, the second column reports the predicted average correlation. To obtain the average, we first calculate the predicted correlation for each firm using firm-specific values of profit margin, expected cash cycle and other parameters of the inventory model and the expressions in table 1. Cross-sectional averages of these correlations are reported as the predicted average correlations in table 5. The other columns in table 5 report the average, standard deviation, median, minimum, 25th percentile, 75th percentile, and maximum value of the distribution of empirically estimated correlations for the sample firms.

and post-1982 data for the forecasting tests. The results are essentially the same as those reported in the text.

The average values of actual serial- and cross-correlations have the same sign as the predicted averages in four of the six cases we examine and the magnitudes are close in five of the six. Specifically, the actual average serial correlations in cash flow changes and accrual changes; cross-correlation between accrual and cash flow changes; and cross-serial correlation between accrual changes and cash flow changes have predicted signs and are relatively close to the predicted values. In addition, the average earnings change correlation is close to the predicted value of zero. In all five cases, the actual average correlations differ from predicted averages by 0.15 or less.

[Table 5]

Average serial correlation in cash flow changes for the sample firms is predicted to be -0.36. The actual average value is -0.28 and the median is -0.29. A t-test of the difference between the predicted and actual average correlations rejects the null of zero difference at 1% alpha-level of significance. This is true for all six cases examined in table 5 and is discussed below. Inferences about statistical significance are based on t-tests that assume cross-sectional independence among the estimated correlations for the sample firms and, therefore, should be interpreted with caution.

The model predicts a serial correlation of -0.40 for accrual changes, whereas the actual average serial correlation is -0.27. Over three quarters of the firms in the sample have a negative point estimate of the serial correlation. There is, however, considerable dispersion (standard deviation = 0.26) in the point estimates of the serial correlations. This suggests that the individual correlations are not estimated very precisely and/or our model of accruals fails to capture the cross-sectional variation in serial correlation in accrual changes in the data.

The simple model predicts zero serial correlation in earnings changes. The average bias-adjusted serial correlation in earnings is -0.02, which is quite close to the predicted value even though it is significantly below zero. While the bias-adjusted serial correlation in earnings is close to zero, consistent with the results in previous literature, we observe an average serial correlation of -0.09 without adjusting for bias. Watts and Leftwich (1977, p. 261) and Dechow (1994, table 2) report mean serial correlation estimates for annual earnings changes of -0.12 and -0.18 respectively.¹¹ Ramakrishnan and Thomas (1995) report that negative serial correlation in annual earnings is more pronounced in recent years.

The small degree of negative serial correlation in earnings changes suggests there might be costs that do not vary with sales (fixed costs) or accrual corrections (or errors)

¹¹While the serial correlation estimates for individual firms for annual earnings tend to be insignificant, estimated serial correlation coefficients are significant for quarterly earnings [see Foster (1977) and Watts and Leftwich (1977, pp. 269-70)].

that induce a correlation in earnings changes. The simple model is modified in sections 5 and 6 to incorporate fixed costs. Another possibility for the negative serial correlation in earnings changes is that the assumption that sales follow a random walk is violated. To assess the sensitivity of the results to the random walk in sales assumption, we separately analyzed the inter-quartile 50% of the sample firms ranked according to the serial correlation in earnings changes. The results are qualitatively indistinguishable from those reported for the entire sample of firms.

Dechow (1994) documents a negative contemporaneous association between accrual changes and cash flow changes. The simple model also predicts a strong negative association between accrual changes and cash flow changes. The predicted correlation is -0.95, compared to the actual average correlation of -0.88. An overwhelming majority of the estimated correlations is negative, with the 75th percentile being -0.86.

By far the largest difference between average actual and predicted correlations is for the contemporaneous correlation between earnings changes and cash flow changes. The average predicted correlation is -0.46 versus average actual correlation of 0.15. The predicted negative correlation is probably surprising to many.¹² Our model generates a negative correlation because changes in cash flows and accruals are negatively correlated. An increase in sales generates an increase in earnings, but tends to generate a decrease in cash flows and an offsetting increase in accruals. The costs associated with sales increases tend to be paid before associated cash flow increases are received, reducing operating cash flows, but increasing working capital accruals.

Introduction of fixed costs that do not vary with sales (see above) will make the predicted correlation between earnings changes and cash flow changes more positive (and hence more in line with the average actual correlation). These costs are common to both earnings and cash flows and hence tend to make the correlation of the changes positive.

As noted earlier in section 3.4, working capital accruals capturing future cash flows should produce a positive cross-serial correlation between current accrual changes (of period t) and future cash flow changes (of period $t+1$). The simple model (incorporating non-zero estimates of θ_1 and θ_2) generates an average predicted correlation of 0.46 for the sample firms. The actual average correlation, 0.31, is smaller than the predicted correlation.

¹² While we estimate the correlation in the first differences, one might also correlate earnings and cash flow levels. Assuming co-integration, the two should be highly positively correlated. The median (mean) levels correlation between cash flows and earnings is 0.56 (0.46), which is below the predicted value under our assumptions of 0.9, but is at least large and positive as one might expect. Part of the difference between

In summary, the average actual correlations match up quite well with the average predicted correlations based on the simple model in five of the six cases reported in table 5. In terms of statistical significance, however, in all five cases the average values of estimated correlations reliably differ from the predicted average correlations. The poor prediction in the remaining case could be due to the simple model ignoring fixed costs. Overall, the simple model is helpful in explaining the actual average correlations among various variables, but modifications are necessary to improve the fit. This is explored in the section 5.

4.4 Cross-sectional correlations

This section examines whether predicted firm and portfolio correlations between earnings changes, accrual changes, and cash flows changes are correlated with actual firm and portfolio correlations. The motivation for using portfolios is that actual and predicted firm correlations are likely to be influenced by sampling errors. Since we use annual data for 10-20 years and assume parameter stationarity over the entire period, we obtain noisy firm-level estimates. Portfolio-level data can be effective in reducing the influence of noise in the firm-level data. It is effective in estimating relations between the underlying variables if portfolio formation is uncorrelated with the noise but is correlated with the underlying variables.

There are several variables (e.g., operating cash cycle, profit margin or actual correlation) on which the sample observations can be ranked and assigned to portfolios. Ranking on one of these variables however, is not likely to be successful. First, the parameter estimates and actual correlations are likely to be dominated by sampling errors, so their ranked values are unlikely to diversify away the sampling error even at the portfolio level (Maddala, 1988, p. 395). Second, in the presence of multiple independent variables, portfolios formed by ranking on any one independent variable generally yields misleading results (Maddala, 1977, p. 273).

To reduce sampling error at the portfolio level, we form portfolios in two different ways. First we rank all the securities on their predicted correlations and assign them to twenty portfolios. Portfolio-level actual and predicted correlations are equal-weighted averages of the individual correlations. We then correlate actual portfolio level correlations with their predicted portfolio correlations.

Second, we form industry portfolios. We believe using the 2-digit SIC code industry classification as the grouping variable has desirable properties. There are

the predicted and actual values of the correlations in the levels is likely due to fixed costs and to deviations from the assumed random walk property for sales and earnings.

systematic differences across industries in their trade and operating cycles due to differences in their investment, financing, and operating activities. Therefore, even at the industry level we expect variation in the underlying parameters that influence the correlations between earnings, cash flows, and accrual changes. In this sense the grouping variable is correlated with the underlying true variables. Noise in the estimated parameters is rooted in the ex post success and failure of the sample firms over the 20 or more years of historical period that is used for parameter estimation. The noise stemming from firm-specific success, failure and other unique experiences will be diversified away at the industry level. The common experiences of the firms within an industry (i.e., the industry factors), however, will not be diversified away. Thus, we expect some benefit from forming industry portfolios, but the noise will not be eliminated.¹³

Table 6 reports the results. Four of the five correlations between the predicted and actual values of firm-specific serial- and cross-correlations are positive and significant at the .05 significance level using one one-sided tests (see the second column in table 6). But, the correlations are generally small in absolute magnitude and the statistical significance might be overstated because of positive cross-correlation. The correlation between predicted and actual cross-correlations between accruals and next-period cash flows is negative and insignificant.

The third column of table 6 reports the correlations between predicted and actual values of the 20 portfolios constructed by ranking firms on their predicted correlations. All five correlations are positive, and four are significant at the .05 level. The absolute values of most of the correlations are high, but this is not surprising given the analysis is at the portfolio level.

[Table 6]

For the industry-level analysis, we form 59 two-digit SIC code industries. For each industry we calculate the simple average of the predicted and actual firm-specific correlations. The fourth column in table 6 reports correlations between the industry-average actual and predicted values of the correlations. All five correlations are positive but only three are significant at the .05 level.

Considering both the firm-level and portfolio-level analyses the correlation between predicted and actual correlations provides some support for the simple model.

¹³ We also performed industry-level analysis by estimating all the correlations using the time series of industry financial variables. That is, we constructed a time series of equal-weighted portfolios of earnings, cash flows, and accruals and estimated the correlation structure using the portfolio-level data. These results are not as strong as those reported in the paper. This might be due in part because the industry-level portfolios are likely to be dominated by extreme realizations of financial variables.

5. Modifications to the simple model

This section enriches the simple model by introducing fixed costs. The model can also be enriched by introducing accrual corrections or errors. The accrual correction specification, however, is similar to that of fixed costs and generates similar results. For that reason, we report only the fixed cost modification. The modifications bring the simple model a step closer to realistic corporate settings. The modifications also help explain some differences between actual correlations and correlations predicted by the simple model.

5.1 Fixed costs

One potential reason for observing both a positive correlation between contemporaneous changes in earnings and cash flows and a small negative serial correlation in earnings changes is the presence of fixed costs, including cash period costs and fixed selling and administrative costs. Fixed costs that do not vary with sales can generate both correlations.¹⁴ Consider fixed costs like property taxes that vary with the assessed value of the property and tax rates. The accounting treatment of these costs is to expense the entire amount as a period cost. The costs thus affect earnings and cash flows identically and do not affect accruals. The common effect on earnings and cash flows generates a positive correlation between earnings and cash flow changes. If the time series process of fixed costs is stationary in levels, the first differences are negatively serially correlated due to overdifferencing a stationary process. The presence of fixed costs therefore induces negative serial correlation in earnings changes.

An alternative, but not mutually exclusive, explanation for the negative serial correlation in earnings changes is errors in accrual forecasts [see Ball and Watts (1979, p. 205) and Ramakrishnan and Thomas (1995)]. Accruals require forecasts and those forecasts are never completely accurate. For example, the accounts-receivable accrual requires a forecast of bad debts. In any year the actual bad debt experience is unlikely to be equal to that forecast. The error, however, is corrected next year and this correction generates the negative serial correlation in earnings. Thus, the presence of errors induces negative serial correlation in earnings changes.¹⁵ Other examples of accruals requiring forecasts (which are revised routinely) include: percentage completion of contracts; estimates of oil and gas reserves and amortization of those reserves; estimated cost of

¹⁴In spite of the label fixed costs, fixed costs are not literally constant through time. These costs are unrelated to the level of sales and over short periods (a year or two) they are relatively fixed.

¹⁵To obtain negative serial correlation in earnings changes, it is not necessary that accrual corrections or errors themselves are negatively serially correlated. If the distribution of errors is relatively stationary and not totally dependent on sales, it still can generate negative serial correlation in earnings changes.

restoring stripped land in mining firms; amortization of mortgage fees based on estimates of mortgage prepayments; and estimates of the useful life of long-lived assets including patents and copyrights. In some of these examples the accrual forecast error and its correction occur over several periods. While it is possible to model accrual errors to generate negative serial correlation in earnings changes, we model only the effect of fixed costs to keep the analytics simple.

To introduce fixed costs, we modify the simple model. Let a_t be fixed costs that follow a white noise process. Assume also that a_t is independent of sales, and its variance is a fraction of the variance of sales changes. In particular, assume the variance of a_t is a proportion (m) of the variance of sales changes (σ^2), $m \sigma^2$.

5.2 Serial correlation in earnings changes

With the addition of fixed costs, the expression for earnings (equation 9) becomes:

$$E_t = \pi S_t - a_t \quad (27)$$

where p is now the contribution margin (sales minus variable costs divided by sales). With this assumption, earnings no longer follows a random walk:

$$E_t = E_{t-1} + \pi \varepsilon_t - a_t + a_{t-1}. \quad (28)$$

The fixed costs generate negative serial correlation in earnings changes:

$$\rho \Delta E_t, \Delta E_{t-1} = -m/(\pi^2 + 2m) \quad (29)$$

Since $m > 0$, there is negative serial correlation in earnings changes. The magnitude of that correlation depends on the relative values of π and m . The lower the ratio of the variance of fixed costs to the variance of sales, the closer to zero is the serial correlation. To generate the observed mean negative serial correlation of approximately -0.1 reported in the literature from our model, m must be equal to $\pi^2/8$. Given our estimate of the average profit margin on sales, π , is 5%, $m = \pi^2/8$ implies the variance of fixed costs as a percentage of the variance of sales changes (i.e., m) is approximately 0.03%. The empirical estimate of m , 7.59%, reported in table 8 (discussed in more detail below), is relatively much larger. Given our empirical model of fixed costs is simplistic and the regression model to obtain m is not estimated precisely, it is likely m is estimated with considerable sampling error (see section 6 for details).

The serial correlation in accrual changes in the presence of fixed costs continues to be -0.5. In the presence of fixed costs and assuming $\theta_1 = \theta_2 = 0$, total accrual in period t is

$$\begin{aligned}
A_t &= E_t - CF_t \\
&= \delta \varepsilon_t
\end{aligned} \tag{30}$$

and

$$\Delta A_t = \Delta \varepsilon_t \tag{31}$$

which is the same as in the model without fixed costs.

Serial correlation in accrual changes, therefore, is

$$\begin{aligned}
\rho \Delta A_t, \Delta A_{t-1} &= -\delta^2 \sigma^2 / 2\delta^2 \sigma^2 \\
&= -0.5.
\end{aligned} \tag{32}$$

The magnitude of the serial correlation in accrual changes is unaffected by the presence of fixed costs because accounting accruals themselves are unaffected by fixed costs. The predicted correlations using the fixed costs model with and without assuming $\theta_1 = \theta_2 = 0$, are listed in table 7.

[Table 7]

5.3 Contemporaneous correlation between operating cash flow changes and earnings changes

One consequence of fixed costs is that cash flows and earnings are affected in the same direction. Algebraically, since fixed costs are assumed to affect the cash flow, it can be written as (assuming $\theta_1 = \theta_2 = 0$)

$$CF_t = \pi S_t - a_t - \delta \varepsilon_t. \tag{33}$$

Combining equation (10) for cash flow change with equation (33) and using equation (28) for earnings change, the contemporaneous covariance between cash flow changes and earnings changes is

$$\begin{aligned}
\text{Cov}(\Delta CF_t, \Delta E_t) &= \text{Cov}\{[(\pi - \delta)\varepsilon_t + \delta\varepsilon_{t-1} + \Delta a_{t-1}], [\pi\varepsilon_t - \Delta a_t]\} \\
&= [\pi(\pi - \delta) + 2m] \sigma^2.
\end{aligned} \tag{34}$$

Therefore, if $2m + \pi^2$ exceeds $\pi\delta$, the contemporaneous covariance between cash flow changes and earnings changes is positive. The constant average profit margin, π , for our sample firms, 4.95% (table 3), and average δ , 0.32 (table 3), suggest m exceeds 0.6% of σ^2 or more than the variability of earnings. This appears to be too large a variability in earnings to be generated by fixed costs or accrual corrections.

6. Tests of the modified model

Assuming $\theta_1 = \theta_2 = 0$, the modified model implies the following forecast error variances when current earnings and current cash flows are separately used to forecast one-period-ahead cash flows:

earnings,

$$\sigma^2(\text{FE}_{t+1}) = (\pi - \delta)^2 \sigma^2 + 2m\sigma^2 \quad (35)$$

and cashflows

$$\sigma^2(\text{FE}_{t+1}) = (\pi - \delta)^2 \sigma^2 + 2m\sigma^2 + \delta^2 \sigma^2 \quad (36)$$

The cash flow-based forecast error variance is larger than the earnings-based forecast error variance by the third term in equation (36), $\delta^2 \sigma^2$. This result also holds for longer forecast horizons. Thus, the modified model implies, like the simple model, that current earnings by itself is a better forecast of future cash flows than current cash flows by itself and that the forecast superiority of earnings is increasing in the expected cash flow cycle, δ . Those implications were tested in section 4 and found generally consistent with the evidence. The modified model correlation predictions, however, do significantly differ from those of the simple model, so this section examines whether predictions based on the modified model are in line with the actual correlations.

The main feature of the modified model is the presence of fixed costs unrelated to the level of sales. This generates positive contemporaneous correlation in earnings and cash flow changes. We begin this section by briefly describing how we estimated contribution margin and fixed costs. These are used in the correlation formulas similar to the use of various parameter values in table 5.

6.1 Estimation of contribution margin and fixed costs

Contribution margin, CM, and the fraction of sales variance that is due to fixed costs, m , are estimated using sales and earnings data for individual firms. Since fixed costs, FC, are not known, we begin with the identity:

$$\text{CM} * \text{Sales} = \text{FC} + \text{Earnings}.$$

Dividing this identity through by CM, one can regress sales on earnings to estimate the unknowns CM and FC:

$$\text{Sales}_t = \lambda_0 + \lambda_1 \text{Earnings}_t + \text{error}_t$$

where λ_0 is an estimate of FC/CM and λ_1 is an estimate of 1/CM. λ_0/λ_1 therefore provides a point estimate of the average fixed costs for a firm over the sample period. The fixed

costs in year t , FC_t , therefore, can be estimated as $(Sales_t/\lambda_1) - Earnings_t$. We use the time-series variances of FC_t and $Sales_t$ to calculate m as the ratio of the two variances.

Firm-specific regressions to estimate CM and m are performed using at least ten annual observations per firm. Table 8 reports descriptive statistics for CM and m . Average value of m is 7.59% and average CM is 17.18%. There is considerable variation in the estimates of CM and m for the sample firms, suggesting both true variation and estimation error. Because m and CM are not observable, we made simplifying assumptions in estimating these for individual firms via the regression of sales on earnings. As a result, we suspect the cross-sectional variation in their estimated values is heavily influenced by sampling error.

[Table 8]

6.2 Average correlation results

The results of comparing average actual with average predicted correlations based on the modified model are reported in table 9. We only report the average actual correlation because selected fractiles of the distribution of actual correlations are reported in table 5. We include predicted correlations for both the simple and modified models. The second column of table 9 reports the model for which results are reported in individual rows of the table.

The presence of fixed costs has very little effect on the serial correlation in cash flow changes compared to that based on the simple model. The predicted correlation using the modified model is -0.37 compared to -0.36 for the simple model. The average observed serial correlation, -0.28, continues to be close to the predicted average correlation.

[Table 9]

In the simple model, accrual changes exhibit a serial correlation of -0.40. In the presence of fixed costs, the predicted correlation is -0.39. The observed serial correlation, -0.27, is quite close to the predicted value. The fixed-cost model predicts negative serial correlation of -0.30 for earnings changes. The estimated average serial correlation, -0.02 thus has the predicted sign, but the difference in the magnitudes of the predicted and actual correlations is large. Thus, the introduction of fixed costs does not satisfactorily model the autocorrelation in earnings changes.

The association between accrual changes and cash flow changes is predicted to be strongly negative under the fixed costs model. Consistent with this prediction, the actual average correlation is -0.88 compared to the predicted value of -0.71. The addition of fixed

costs performs the intended function because the modified model predicts a positive contemporaneous correlation of 0.07 between earnings changes and cash flow changes. This is comparable to the actual average correlation of 0.15.

Accruals continue to forecast one-period-ahead cash flow changes in the modified model. The predicted correlation, 0.44, is only slightly smaller than that using the simple model, 0.46. The actual correlation, 0.31, is quite close to that predicted by the modified model.

In summary, the actual correlations between changes in earnings, accruals, and operating cash flows have predicted signs in all six cases that we estimate. The effect of modifying the simple model to incorporate fixed costs is to generally narrow the differences between predicted and actual average correlations. However, the modification was motivated by the lack of correspondence between predicted and actual correlations. So while the modified model is helpful in explaining the average actual correlations among various variables, not all of its tests are predictive.

6.3. Cross-sectional correlations

The last three columns of table 9 report the correlations between predicted and actual correlations at the firm and portfolio levels for the modified model. At the firm level (fifth column of table 9), five of the six correlations are positive and significant at the .05 level using a one-sided test. The exception is the correlation between the predicted and actual correlations between current changes in accruals and future changes in cash flows.

The sixth column of table 9 reports the correlations for the 20 portfolios constructed using predicted correlations. All six correlations are positive and five are significant at the .05 level using a one-sided test. The exception is again the correlation between the predicted and actual correlations between current changes in accruals and future changes in cash flows.

The results for the industry portfolios (column seven) are similar to those for the firm-level and predicted correlation portfolios except that the correlation between predicted and actual earnings serial correlation is negative and insignificant. As for the simple model, for the modified model overall the cross-sectional correlation results provide some support for the model.

7. Summary and conclusions

In this paper we develop a model of operating cash flows and the formal accounting process by which those cash flows are converted into accounting earnings. The model can explain why operating cash flow changes are negatively correlated, how accruals offset that

negative correlation to produce earnings changes that are much less negatively serially correlated and why current earnings by itself is a better forecast of future operating cash flows than current operating cash flows by itself. That last explanation can in turn help explain why earnings rather than current operating cash flows tend to be used in valuation and in performance measures.

The model has two versions: one in which all expenses are variable; and one that allows for both variable and fixed expenses. The latter version was developed to explain some correlations not well-explained by the first version and some of its correlation predictions were developed from knowledge of the data. Both model versions generate the prediction that current earnings should better predict future operating cash flows than current cash flows and that the difference in accuracy of the two predictions should be a positive function of the firm's expected cash flow cycle. Serial correlations and cross-correlations are predicted for earnings, operating cash flows and accruals at the firm and portfolio levels and for the whole sample on average using estimates of model parameters for both model versions.

We test the predictions on a sample of 1,337 firms. Current earnings are found to be a better forecast of future cash flows than current cash flows as predicted by the model. And, as also predicted by the model, the difference in the ability of current earnings and current cash flows to predict future cash flows is a positive function of the firm's expected operating cash cycle.

The average actual correlations for the sample are generally quite close to those predicted with the sample parameters under both versions (though they are significantly different). For the simple (all variable expense) model four of the six predicted average correlations have the same sign as the average actual correlation. One of the other two is serial correlation in earnings changes which has an average predicted correlation of zero and an average actual correlation of $-.02$. For the modified (variable and fixed expense) version the signs of the average predicted and actual correlations match for all six correlations investigated. However, the modification to the model was made to generate a negative serial correlation in earnings changes.

Finally, we correlate the actual and predicted correlations at the firm and portfolio levels. Most correlations are significantly positive consistent with a relation between the actual and predicted correlations, but of relatively low magnitude. The correlations magnitudes are substantially higher at the portfolio level suggesting there is noise in individual firm estimates.

Overall, the evidence suggests the models have some statistical explanatory power. However, the model also contributes intuitive explanations for phenomena that were not

previously apparent and suggests potentially fruitful lines of future inquiry. An example of an intuitive explanation that was not apparent is the explanation for the observed negative serial correlation in firms' operating cash flow changes. On average firms provide longer credit terms to their customers than they receive from their suppliers. That fact, combined with firms' tendency to adjust inventories to sales shocks at the annual level, means the cash outflows associated with those sales shocks precede cash inflows associated with the shock. Thus a sales increase generates first a net cash outflow and then a net cash inflow and hence a negative correlation in cash flow changes. The explanation extends to the small minority of firms that have positive serial correlation in cash flow changes. Those are firms with operating cash flow cycles so short that the spreading of the profit on the sales shock across time dominates. These explanations could prove valuable in financial statement analysis and lead to the development of useful benchmarks at the industry level.

One apparent line of further inquiry is to incorporate additional accruals in the model. The model and results in this paper flesh out Dechow's contention that working capital accruals incorporate the negative correlation in operating cash flows in earnings and make earnings more timely than operating cash flows (in the sense of being more correlated with contemporaneous stock returns). The approach can be carried further to incorporate in the model the effect of individual accruals other than accounts receivable, accounts payable and inventory. Within working capital accruals for example, the effects of allowance for doubtful accounts on the earnings correlations and the timeliness of earnings could be investigated. A more difficult extension would be to incorporate investment accruals in the model. This would involve explanation of when investment outlays are capitalized and when they are expensed.¹⁶ A related line of inquiry would be to use the model to evaluate the effects of individual accounting standards.

The model can also contribute to the specification of non-discretionary accrual models such as that proposed by Jones (1991). The Jones model expresses accruals as a direct function of changes in sales. Our model can explain how the coefficient on sales in the Jones model would vary across firms and lead to better specifications of the relation.

¹⁶ Under the contracting approach this issue would appear to involve the ability to verify the future cash flows from the investment, the likelihood of receiving the cash flows and whether they are easily determinable.

Appendix

Inventory-level changes and sales changes

In this appendix we describe how we estimate the parameters of the simple model with inventory that is outlined in section 3. Following Bernard and Stober (1989), the inventory model assumes that a firm's inventory at the end of period t consists of a target level and a deviation from that target. Target inventory is a constant fraction of forecasted sales for the next period. Since we assume sales follow a random walk, target inventory equals $\gamma_1 S_t(1 - \pi)$, where $\gamma_1 > 0$ and S_t is sales in period t . Target inventory will be maintained if a firm increases its inventory in response to sales changes by $\gamma_1 \Delta S_t(1 - \pi)$. Actual inventory will deviate from the target in part because actual sales differ from forecasts and there is an inventory build up or liquidation. The deviation is given by $\gamma_2[\gamma_1\{E_{t-1}(S_t) - S_t\}(1 - \pi)] = \gamma_2[\gamma_1(S_{t-1} - S_t)(1 - \pi)]$, where γ_2 is a constant that captures the speed with which a firm adjusts its inventory to the target level. If γ_2 is 0, then the firm does not deviate from the target, whereas if $\gamma_2 = 1$, the firm makes no inventory adjustment. γ_1 and γ_2 are estimated empirically by regressing a firm's inventory at the end of a year on sales for the year and change in sales over the preceding year:

$$INV_t = \gamma_1 S_t + \gamma_2 \Delta S_t + \text{err}_t \quad (\text{A1})$$

and $\gamma_1 = \gamma_1/(1 - \pi)$, and $\gamma_2 = -\gamma_2/\gamma_1$, where π is the average profit margin of a firm.

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Table 1

Predicted serial correlations and cross-correlations among cash flows, earnings, and accruals using the simple model with and without the assumption that $\theta_1 = \theta_2 = 0$

Correlation between	Correlation using the simple model	Correlation using the simple model assuming $\theta_1 = \theta_2 = 0$
$\Delta CF_t, \Delta CF_{t-1}$	$\frac{\delta(\pi - \delta) + 2\theta_1(2\delta - \pi - 2\theta_1) + \theta_2(\pi - 3\delta + 7\theta_1 - 4\theta_2)}{\pi^2 + 2\delta^2 - 2\delta\pi + 6\theta_1^2 + 6\theta_2^2 - 6\delta\theta_1 + 2\pi\theta_1 - 8\theta_1\theta_2 + 2\delta\theta_2}$	$\delta(\pi - \delta)/(\pi^2 + 2\delta^2 - 2\delta\pi)$
$\Delta A_t, \Delta A_{t-1}$	$\frac{-\delta^2 + 4\theta_1(\delta - \theta_1) - \theta_2(2\delta + 7\theta_1 - 4\theta_2)}{2\delta^2 - 6\theta_1(\delta - \theta_1) + 6\theta_2^2 - 8\theta_1\theta_2 + 2\delta\theta_2}$	-0.5
$\Delta E_t, \Delta E_{t-1}$	0	0
$\Delta A_t, \Delta CF_t$	$\{[\pi^2 + 2\delta^2 - 2\delta\pi + 6\theta_1^2 + 6\theta_2^2 - \frac{\pi(\delta - \theta_1) - 2\delta^2 + 6(\delta\theta_1 - \theta_1^2 - \theta_2^2) + 8\theta_1\theta_2 - 2\delta\theta_2}{2\delta^2 - 6\theta_1(\delta - \theta_1) + 6\theta_2^2 - 8\theta_1\theta_2 + 2\delta\theta_2}]\}^{0.5}$	$\delta(\pi - \delta)/[2(\pi^2 - 2\delta\pi + 2\delta^2)]^{0.5}$
$\Delta E_t, \Delta CF_t$	$[\pi^2 + 2\delta^2 - 2\delta\pi + 6\theta_1^2 + \frac{\pi - \delta + \theta_1}{6\theta_2^2 - 6\delta\theta_1 + 2\pi\theta_1 - 8\theta_1\theta_2 + 2\delta\theta_2}]^{0.5}$	$(\pi - \delta)/[(\pi^2 - 2\delta\pi + 2\delta^2)]^{0.5}$
$\Delta A_t, \Delta CF_{t+1}$	$\{[\pi^2 + 2\delta^2 - 2\delta\pi + 6\theta_1^2 + 6\theta_2^2 - 6\delta\theta_1 + \frac{\delta^2 - 4\delta\theta_1 + 4\theta_1^2 + 3\delta\theta_2 - 7\theta_1\theta_2 + 4\theta_1^2}{2\pi\theta_1 - 8\theta_1\theta_2 + 2\delta\theta_2}]\}^{0.5}$	$\delta/[2(\pi^2 - 2\delta\pi + 2\delta^2)]^{0.5}$

E = earnings per share before extraordinary items and discontinued operations;

CF = cash flow from operations, which is calculated as operating income before depreciation minus interest minus taxes minus changes in noncash working capital;

A = operating accruals, which are earnings minus cash flow from operations, or E - CF.

Δ is the first difference operator.

π = profit margin on sales = the ratio of earnings (before extraordinary items and discontinued operations) to sales, averaged across the number years for which data are available for a firm.

δ = target operating cash cycle = $\alpha_t + (1 - \pi)\gamma_1 - \beta_t(1 - \pi)$,

where $\alpha_t = [(AR_t + AR_{t-1})/2\text{Sales}_t]$,

$\beta_t = [(AP_t + AP_{t-1})/(2\text{Sales}_t(1 - \pi))]$,

AR_t = accounts receivables,

AP_t = accounts payable, all at the end of year t,

Sales_t = sales during year t,

γ_1 = target inventory as a fraction of forecasted cost of sales, and

γ_2 = speed with which inventory adjusts to the target level.

γ_1 and γ_2 are estimated empirically by regressing a firm's inventory at the end of a year on sales for the year and change in sales over the preceding year:

$$\text{Inv}_t = g_1 \text{Sales}_t + g_2 \Delta \text{Sales}_t + \text{err}_t,$$

and $\gamma_1 = g_1 / (1 - \pi)$, and $\gamma_2 = -g_2 / g_1$.

$\theta_1 = \gamma_1 (1 - \pi) [\beta + \gamma_2 (1 - \beta)]$, and

$\theta_2 = \beta \gamma_1 \gamma_2 (1 - \pi)$.

Table 2

Descriptive statistics on selected variables: Sample of 1,337 firms, data from 1963-92

Variable	Mean	Std. Dev.	Min	Q1	Med	Q3	Max
Mean E	1.13	0.95	-2.15	0.51	0.93	1.53	8.54
Mean ΔE	0.05	0.18	-1.24	-0.04	0.04	0.13	1.32
Var(ΔE)	0.85	1.14	0.00	0.17	0.43	1.06	9.92
Mean CF	1.63	1.61	-4.36	0.56	1.14	2.24	12.60
Mean ΔCF	0.04	0.36	-3.07	-0.10	0.04	0.18	2.27
Var(ΔCF)	4.94	6.14	0.02	0.93	2.59	6.38	45.29
Mean A	-0.50	1.04	-10.14	-0.90	-0.26	0.03	7.10
Mean ΔA	0.01	0.36	-2.53	-0.13	-0.01	0.12	2.44
Var(ΔA)	5.35	6.69	0.01	0.96	2.71	7.10	44.93
Mean Sales	31.32	30.92	0.82	12.05	21.63	39.72	343.42
Mean Δ Sales	1.19	2.85	-8.66	-0.40	0.74	2.17	20.74
Var of Δ Sales	82.84	103.05	0.07	14.85	44.15	113.23	828.60

Sample: The sample consists of 22,776 observations on 1,337 firms from the Compustat Annual Industrial and Annual Research tapes with at least ten earnings, accruals, and cash flow observations in first differences. The per share values are adjusted for changes in share capital and splits etc. Observations with largest and smallest 1% values of earnings, accruals, cash flows, and sales are excluded from the sample.

E = earnings per share before extraordinary items and discontinued operations;

CF = cash flow per share from operations, which is calculated as operating income before depreciation minus interest minus taxes minus changes in noncash working capital;

A = operating accruals per share, which are earnings minus cash flow from operations, or E - CF.

S = sales per share.

Δ is the first difference operator and Var is variance.

The values reported in the table for the level and first-difference in each variable are calculated using 1,337 firm-specific average values. Descriptive statistics for variances are based on a sample of 1,337 variance observations for the sample firms. All numbers are in dollars.

Table 3
Descriptive statistics on model parameters: Sample of 1,337 firms, data from 1963-92

Variable	Mean	Std. Dev.	Min	Q1	Median	Q3	Max
π	0.0495	0.0423	-0.1435	0.0260	0.0426	0.0637	0.3508
α	0.30	0.17	0.00	0.22	0.29	0.37	2.64
β	0.14	0.08	0.02	0.10	0.12	0.17	1.27
γ_1	0.16	0.10	0.00	0.09	0.15	0.22	1.00
γ_2	0.00	0.59	-1.00	-0.41	0.03	0.41	1.00
δ	0.32	0.20	-0.22	0.18	0.31	0.43	2.75
θ_1	0.02	0.08	-0.46	-0.02	0.01	0.06	0.38
θ_2	0.00	0.02	-0.29	-0.01	0.00	0.01	0.11

Sample: The sample consists of 22,776 observations on 1,337 firms from the Compustat Annual Industrial and Annual Research tapes with at least ten earnings, accruals, and cash flow observations in first differences. The per share values are adjusted for changes in share capital and splits etc. Observations with largest and smallest 1% values of earnings, accruals, cash flows, and sales are excluded from the sample.

π = profit margin on sales = the ratio of earnings (before extraordinary items and discontinued operations) to sales, averaged across the number years for which data are available for a firm.

$\alpha_t = [(AR_t + AR_{t-1})/2\text{Sales}_t]$,

$\beta_t = [(AP_t + AP_{t-1})/(2\text{Sales}_t(1 - \pi))]$,

AR_t = accounts receivables,

AP_t = accounts payable, all at the end of year t ,

$\delta = [\alpha + (1 - \pi)\gamma_1 - \beta(1 - \pi)]$, where

γ_1 = target inventory as a fraction of forecasted cost of sales, and

γ_2 = speed with which inventory adjusts to the target level.

γ_1 and γ_2 are estimated empirically by regressing a firm's inventory at the end of a year on sales for the year and change in sales over the preceding year:

$$\text{Inv}_t = g_1 \text{Sales}_t + g_2 \Delta\text{Sales}_t + \text{err}_t,$$

where Inv_t = inventory, Sales_t = sales during year t and $\gamma_1 = g_1/(1 - \pi)$, and $\gamma_2 = -g_2/g_1$. γ_1 is truncated above at 1, and γ_2 is truncated above at 1 and below at -1.

$\theta_1 = \gamma_1(1 - \pi)[\beta + \gamma_2(1 - \beta)]$, and

$\theta_2 = \beta \gamma_1 \gamma_2 (1 - \pi)$.

θ_1 and θ_2 parameters appear in expressions for changes in cash flows and accruals.

Table 4

Means of firm-specific standard deviations of forecast errors: Current operating cash flows and earnings as predictors of future cash flows

Sample	OCF _t fore-casted using	Mean standard deviation	OCF _t fore-casted using	Mean standard deviation	Mean pairwise difference	t-statistic
All	OCF _{t-1}	1.89	E _{t-1}	1.60	0.29	17.87
	OCF _{t-2}	2.06	E _{t-2}	1.59	0.47	28.73
	OCF _{t-3}	2.10	E _{t-3}	1.65	0.46	28.05
Q1	OCF _{t-1}	1.63	E _{t-1}	1.41	0.23	7.12
	OCF _{t-2}	1.92	E _{t-2}	1.57	0.35	12.27
	OCF _{t-3}	2.06	E _{t-3}	1.72	0.35	13.17
Q2	OCF _{t-1}	1.88	E _{t-1}	1.62	0.27	8.47
	OCF _{t-2}	2.07	E _{t-2}	1.66	0.42	12.50
	OCF _{t-3}	2.13	E _{t-3}	1.67	0.45	13.54
Q3	OCF _{t-1}	1.94	E _{t-1}	1.60	0.34	12.56
	OCF _{t-2}	2.03	E _{t-2}	1.53	0.51	15.57
	OCF _{t-3}	2.05	E _{t-3}	1.58	0.47	13.06
Q4	OCF _{t-1}	2.08	E _{t-1}	1.63	0.31	8.44
	OCF _{t-2}	2.21	E _{t-2}	1.62	0.59	17.53
	OCF _{t-3}	2.18	E _{t-3}	1.62	0.55	17.01

Sample: The sample consists of 22,776 observations on 1,337 firms from the Compustat Annual Industrial and Annual Research tapes with at least ten earnings, accruals, and cash flow observations in first differences. The per share values are adjusted for changes in share capital and splits etc. Observations with largest and smallest 1% values of earnings, accruals, cash flows, and sales are excluded from the sample.

E = earnings per share before extraordinary items and discontinued operations;
 OCF = cash flow per share from operations, which is calculated as operating income before depreciation minus interest minus taxes minus changes in noncash working capital;
 Q1-Q4 are first through fourth quartiles of firms ranked according to their operating cycles, estimated as the average days receivables and inventory minus average days accounts payable.

Table 5

Predicted and actual values of serial correlations and cross-correlations between cash flow changes, accrual changes, and earnings changes for an average firm using the simple model: Sample of 1,337 firms, data from 1963-92

Correlation between	Predicted correlations using average parameter values	Actual correlations						
		Mean	Std. Dev	Min	Q1	Med	Q3	Max
$\Delta CF_t, \Delta CF_{t-1}$	-0.36	-0.28*	0.26	-0.86	-0.46	-0.29	-0.11	0.61
$\Delta A_t, \Delta A_{t-1}$	-0.40	-0.27*	0.26	-0.84	-0.46	-0.29	-0.09	0.74
$\Delta E_t, \Delta E_{t-1}$	0.00	-0.02*	0.31	-0.79	-0.24	-0.02	0.18	1.00
$\Delta A_t, \Delta CF_t$	-0.95	-0.88*	0.15	-0.99	-0.97	-0.93	-0.86	0.41
$\Delta E_t, \Delta CF_t$	-0.46	0.15*	0.41	-0.95	-0.14	0.15	0.47	0.99
$\Delta A_t, \Delta CF_{t+1}$	0.46	0.31*	0.27	-0.56	0.14	0.33	0.50	0.94

Sample: The sample consists of 22,776 observations on 1,337 firms from the Compustat Annual Industrial and Annual Research tapes with at least ten earnings, accruals, and cash flow observations in first differences. The per share values are adjusted for changes in share capital and splits etc. Observations with largest and smallest 1% values of earnings, accruals, cash flows, and sales are excluded from the sample.

E = earnings per share before extraordinary items and discontinued operations;
 CF = cash flow per share from operations, which is calculated as operating income before depreciation minus interest minus taxes minus changes in noncash working capital;
 A = operating accruals per share, which are earnings minus cash flow from operations, or E - CF.
 S = sales per share.

Δ is the first difference operator.

Predicted correlation is average of the predicted correlations for individual firms in the sample. Predicted correlation of an individual firm is based on the estimated values of the parameters of the simple inventory model. The parameters and the predicted correlation are given in table 1.

Actual values of serial correlations (i.e., correlations between $\Delta CF_t, \Delta CF_{t-1}$; $\Delta A_t, \Delta A_{t-1}$; and $\Delta E_t, \Delta E_{t-1}$) are adjusted for small sample bias equal to $-1/(T - 1)$, where T is the number of time series observations.

* Significantly different from the predicted mean correlation at 1% significance level using a t-test for difference in means or a t-test for the mean of the pairwise differences between the actual and predicted correlations.

Table 6

Correlation between predicted and actual correlations at the firm level and portfolio level: Sample of 1,337 firms, 20 portfolios formed on ranked predicted correlations and 59 portfolios representing 59 two-digit SIC code industries, data from 1963-92

Correlation between	Correlation between predicted and actual correlations (p value)		
	Firm level	Portfolio level Predicted correlation	Portfolio level Industry
$\Delta CF_t, \Delta CF_{t-1}$	0.06 (0.02)	0.41 (0.04)	0.07 (0.29)
$\Delta A_t, \Delta A_{t-1}$	0.04 (0.09)	0.29 (0.11)	0.25 (0.03)
$\Delta E_t, \Delta E_{t-1}$	NA	NA	NA
$\Delta A_t, \Delta CF_t$	0.07 (0.01)	0.41 (0.04)	0.24 (0.04)
$\Delta E_t, \Delta CF_t$	0.15 (0.00)	0.61 (0.04)	0.31 (0.01)
$\Delta A_t, \Delta CF_{t+1}$	-0.02 (0.73)	0.00 (0.99)	0.12 (0.18)

Sample: The sample consists of 22,776 observations on 1,337 firms from the Compustat Annual Industrial and Annual Research tapes with at least ten earnings, accruals, and cash flow observations in first differences. The per share values are adjusted for changes in share capital and splits etc. Observations with largest and smallest 1% values of earnings, accruals, cash flows, and sales are excluded from the sample.

E = earnings per share before extraordinary items and discontinued operations;
 CF = cash flow per share from operations, which is calculated as operating income before depreciation minus interest minus taxes minus changes in noncash working capital;
 A = operating accruals per share, which are earnings minus cash flow from operations, or E - CF.
 S = sales per share.
 Δ is the first difference operator.

Table 7

Predicted serial correlations and cross-correlations among cash flows, earnings, and accruals using the modified model with and without the assumption that $\theta_1 = \theta_2 = 0$.

Correlation between	Correlation using the modified model	Correlation using the modified model assuming $\theta_1 = \theta_2 = 0$
$\Delta CF_t, \Delta CF_{t-1}$	$\frac{\delta(\pi - \delta) + 2\theta_1(2\delta - \pi - 2\theta_1) + \theta_2(\pi - 3\delta + 7\theta_1 - 4\theta_2) - m}{\pi^2 + 2\delta^2 - 2\delta\pi + 6\theta_1^2 + 6\theta_2^2 - 6\delta\theta_1 + 2\pi\theta_1 - 8\theta_1\theta_2 + 2\delta\theta_2 + 2m}$	$\frac{\delta(\pi - \delta) - m}{(\pi^2 + 2\delta^2 - 2\pi\delta + 2m)}$
$\Delta A_t, \Delta A_{t-1}$	$\frac{-\delta^2 + 4\theta_1(\delta - \theta_1) - \theta_2(2\delta + 7\theta_1 - 4\theta_2)}{2\delta^2 - 6\theta_1(\delta - \theta_1) + 6\theta_2^2 - 8\theta_1\theta_2 + 2\delta\theta_2}$	-0.5
$\Delta E_t, \Delta E_{t-1}$	$-m/(\pi^2 + 2m)$	$-m/(\pi^2 + 2m)$
$\Delta A_t, \Delta CF_t$	$\{[\pi^2 + 2\delta^2 - 2\delta\pi + 6\theta_1^2 + 6\theta_2^2 - 6\delta\theta_1 + 2\pi\theta_1 - 8\theta_1\theta_2 + 2\delta\theta_2 + 2m][2\delta^2 - 6\theta_1(\delta - \theta_1) + 6\theta_2^2 - 8\theta_1\theta_2 + 2\delta\theta_2]\}^{0.5}$	$[2(\pi^2 - 2\delta\pi + 2\delta^2 + 2m)]^{0.5}$
$\Delta E_t, \Delta CF_t$	$\frac{\pi - \delta + \theta_1 + 2m}{[\pi^2 + 2\delta^2 - 2\delta\pi + 6\theta_1^2 + 6\theta_2^2 - 6\delta\theta_1 + 2\pi\theta_1 - 8\theta_1\theta_2 + 2\delta\theta_2 + 2m]^{0.5}[\pi^2 + 2m]^{0.5}}$	$\frac{\pi(\pi - \delta) + 2m}{[(\pi^2 - 2\pi\delta + 2\delta^2 + 2m)(\pi^2 + 2m)]^{0.5}}$
$\Delta A_t, \Delta CF_{t+1}$	$\frac{\delta^2 - 4\delta\theta_1 + 4\theta_1^2 + 3\delta\theta_2 - 7\theta_1\theta_2 + 4\theta_1^2}{\{[\pi^2 + 2\delta^2 - 2\delta\pi + 6\theta_1^2 + 6\theta_2^2 - 6\delta\theta_1 + 2\pi\theta_1 - 8\theta_1\theta_2 + 2\delta\theta_2 + 2m][2\delta^2 - 6\theta_1(\delta - \theta_1) + 6\theta_2^2 - 8\theta_1\theta_2 + 2\delta\theta_2]\}^{0.5}}$	$\delta/[2(\pi^2 - 2\delta\pi + 2\delta^2 + 2m)]^{0.5}$

E = earnings per share before extraordinary items and discontinued operations;

CF = cash flow from operations, which is calculated as operating income before depreciation minus interest minus taxes minus changes in noncash working capital;

A = operating accruals, which are earnings minus cash flow from operations, or E - CF.

Δ is the first difference operator.

π = profit margin on sales = the ratio of earnings (before extraordinary items and discontinued operations) to sales, averaged across the number years for which data are available for a firm.

δ = target operating cash cycle = $\alpha_t + (1 - \pi)\gamma_t - \beta_t(1 - \beta)$,

where α_t = $[(AR_t + AR_{t-1})/2\text{Sales}_t]$,

β_t = $[(AP_t + AP_{t-1})/(2\text{Sales}_t(1 - \pi))]$,

AR_t = accounts receivables,

AP_t = accounts payable, all at the end of year t,

Sales_t = sales during year t,

γ_1 = target inventory as a fraction of forecasted cost of sales, and

γ_2 = speed with which inventory adjusts to the target level.

γ_1 and γ_2 are estimated empirically by regressing a firm's inventory at the end of a year on sales for the year and change in sales over the preceding year:

$$\text{Inv}_t = g_1 \text{Sales}_t + \gamma_2 \Delta \text{Sales}_t + \text{err}_t,$$

and $\gamma_1 = g_1 / (1 - \pi)$, and $\gamma_2 = -\gamma_2 / \gamma_1$.

$\theta_1 = \gamma_1(1 - \pi)[\beta + \gamma_2(1 - \beta)]$, and

$\theta_2 = \beta \gamma_1 \gamma_2 (1 - \pi)$.

CM = contribution margin and m = the fraction of sales variance that is due to errors in accrual forecasts and/or fixed costs. These are estimated using the following regression (see section 6.1 for details):

$$\text{Sales}_t = \theta_0 + \theta_1 \text{Earnings}_t + \text{error}_t$$

where θ_0 is an estimate of FC/CM , where FC is fixed costs, and θ_1 is an estimate of $1/\text{CM}$. Therefore, $\text{FC}_t = (\text{Sales}_t / \theta_1) - \text{Earnings}_t$. m is the ratio of time series variances of FC_t s and sales.

Table 8

Descriptive statistics on model parameters: Sample of 1337 firms, data from 1963-92

Variable	Mean	Std. Dev.	Min	Q1	Median	Q3	Max
m	7.59%	15.06	0.00	0.25	1.21	6.67	87.99
CM	17.18%	16.79	1.02	6.43	11.06	21.41	99.52

Sample: The sample consists of 22,776 observations on 1,337 firms from the Compustat Annual Industrial and Annual Research tapes with at least ten earnings, accruals, and cash flow observations in first differences. The per share values are adjusted for changes in share capital and splits etc. Observations with largest and smallest 1% values of earnings, accruals, cash flows, and sales are excluded from the sample.

CM = contribution margin and m = the fraction of sales variance that is due to errors in accrual forecasts and/or fixed costs. These are estimated using the following regression (see section 4.1 for details):

$$\text{Sales}_t = \lambda_0 + \lambda_1 \text{Earnings}_t + \text{error}_t$$

where λ_0 is an estimate of FC/CM over the sample period, where FC is fixed costs, and λ_1 is an estimate of 1/CM. Therefore, $\text{FC}_t = (\text{Sales}_t / \lambda_1) - \text{Earnings}_t$. m is the ratio of time series variances of FC_t s and sales.

Table 9

Predicted and actual values of correlations between cash flow changes, accrual changes, and earnings changes and correlations between the predicted and actual correlations at the firm level and industry level: Sample of 1,337 firms, and 59 two-digit SIC code industries, data from 1963-92

Correlation between	Model	Predicted correlations	Actual correlations	Correlation between predicted and actual correlations (p-value)		
				Firm level	Portfolio level Predicted correlation	Industry
$\Delta CF_t, \Delta CF_{t-1}$	Simple	-0.36	-0.28*	0.06 (0.02)	0.41 (0.04)	0.07 (0.29)
	Fixed costs	-0.37		0.09 (0.00)	0.39 (0.05)	0.24 (0.03)
$\Delta A_t, \Delta A_{t-1}$	Simple	-0.40	-0.27*	0.04 (0.09)	0.29 (0.11)	0.25 (0.03)
	Fixed costs	-0.39		0.04 (0.09)	0.44 (0.03)	0.30 (0.01)
$\Delta E_t, \Delta E_{t-1}$	Simple	0.00	-0.02	NA	NA	NA
	Fixed costs	-0.30		0.12 (0.00)	0.71 (0.00)	-0.09(0.48)
$\Delta A_t, \Delta CF_t$	Simple	-0.95	-0.88*	0.07 (0.01)	0.41 (0.04)	0.24 (0.04)
	Fixed costs	-0.71		0.37 (0.00)	0.40 (0.04)	0.47 (0.00)
$\Delta E_t, \Delta CF_t$	Simple	-0.46	0.15*	0.15 (0.00)	0.61 (0.00)	0.31 (0.01)
	Fixed costs	0.07		0.03 (0.11)	0.37 (0.05)	0.25 (0.03)
$\Delta A_t, \Delta CF_{t+1}$	Simple	0.46	0.31*	-0.02 (0.73)	0.00 (0.99)	0.12 (0.18)
	Fixed costs	0.44		-0.02 (0.74)	0.05 (0.42)	-0.04 (0.79)

Sample: The sample consists of 22,776 observations on 1,337 firms from the Compustat Annual Industrial and Annual Research tapes with at least ten earnings, accruals, and cash flow observations in first differences. The per share values are adjusted for changes in share capital and splits etc. Observations with largest and smallest 1% values of earnings, accruals, cash flows, and sales are excluded from the sample.

E = earnings per share before extraordinary items and discontinued operations;

CF = cash flow per share from operations, which is calculated as operating income before depreciation minus interest minus taxes minus changes in noncash working capital;

A = operating accruals per share, which are earnings minus cash flow from operations, or $E - CF$.

S = sales per share.

Δ is the first difference operator.

Predicted correlation is average of the predicted correlations for individual firms in the sample. Each predicted correlation of an individual firm is based on the estimated values of the parameters of the modified inventory model. The parameters and the predicted correlation are given in table 5. Actual correlations are estimated for each firm using firm-level time series data of at least 10 years. Actual values of serial correlations (i.e., correlations between ΔCF_t , ΔCF_{t-1} ; ΔA_t , ΔA_{t-1} ; and ΔE_t , ΔE_{t-1}) are adjusted for small sample bias equal to $-1/(T - 1)$, where T is the number of time series observations.

Industry-level predicted and actual correlations are simple averages of the firm-specific predicted and actual correlations. Industry is defined using the 2-digit SIC code classification. There are 59 industries.

* Significantly different from the predicted mean correlation at 1% significance level using a t-test for difference in means.