JOURNAL OF Accounting & Economics

ELSEVIER Journal of Accounting and Economics 25 (1998) 133–168

The relation between earnings and cash flows

Patricia M. Dechow[a], S.P. Kothari[b,*], Ross L. Watts[b]

[a] School of Business Administration, University of Michigan, Ann Arbor, MI 48109-1234, USA
[b] William E. Simon Graduate School of Business Administration, University of Rochester, Rochester, NY 14627, USA

Received 1 December 1995; accepted 1 August 1998

Abstract

A model of earnings, cash flows and accruals is developed assuming a random walk sales process, variable and fixed costs, and that the only accruals are accounts receivable and payable, and inventory. The model implies earnings better predict future operating cash flows than 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 and cash flow forecast implications and correlation predictions are generally consistent with the data. © 1998 Elsevier Science B.V. All rights reserved.

JEL classification: M41, G20

Keywords: Accruals; Cash flows; Earnings; Correlations

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 for the prominence of accounting earnings and the reasons for its usage have been offered. One explanation is that earnings reflects cash flow forecasts (e.g., Beaver, 1989, p. 98; Dechow, 1994) and has a higher

* Corresponding author. Tel.: (716) 275-3956; fax: (716) 442-6323; e-mail: kothari@ssb.rochester.edu.

PII: S0165-4101(98)00020-2

correlation with value than does current cash flow (e.g., Watts, 1977; Dechow, 1994). 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.

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 predictions for: (i) the relative abilities of earnings and operating cash flows to predict future operating cash flows; (ii) firms' time-series properties of operating cash flows, accruals and earnings; and (iii) 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 why there is negative serial correlation in operating cash flow changes. 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. 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.

Accruals' effects 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 the 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 the 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., a plant's cost) are associated with cash flows over much longer and more variable time periods. For that reason we model and investigate the effect of working capital accruals on the prediction of, and serial correlation in, operating cash flows, i.e., cash flows after removing investment and financing accruals.

[1] Many 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).

Section 2 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 2 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 3 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 3 estimates the cross-sectional correlation between predicted correlations and actual correlation estimates. Section 4 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 5 investigates whether the implications of the modified model are consistent with the evidence. Section 6 summarizes the paper and provides suggestions for future research.

2. A model of earnings, operating cash flows and accruals

This section models 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.

2.1. The 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).

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

$$S_t = S_{t-1} + \varepsilon_t, \tag{1}$$

where ε_t is a random variable with variance σ^2 and 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 0.17, 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).[2]

The relation between sales and cash flow from sales is not one-to-one because some 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

$$\mathrm{AR}_t = \alpha S_t. \tag{2}$$

The accounts receivable accrual incorporates future cash flow forecasts (collection 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 4 we 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 that cost will be recovered, the cost is capitalized and excluded from the expense. In essence, the inventory cost is a conservative forecast of the future cash flows from inventory. We assume inventory is carried 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 $\gamma_1 > 0$.[3] Target inventory is maintained if a firm increases its inventory in

[2] 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 tenor of the results are unchanged.

[3] 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.

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

$$\mathrm{INV}_t = \gamma_1(1-\pi)S_t - \gamma_1\gamma_2(1-\pi)\varepsilon_t. \tag{3}$$

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

$$P_t = (1-\pi)S_t + \gamma_1(1-\pi)\varepsilon_t - \gamma_1\gamma_2(1-\pi)\Delta\varepsilon_t. \tag{4}$$

If a firm purchases all its inputs just in time so inventory is zero ($\gamma_1 = 0$), purchases just equal expense for the period $(1-\pi)S_t$. The second term in Eq. (4) consists of the purchases necessary to adjust inventory for the change in target inventory, $\gamma_1(1-\pi)\varepsilon_t$. The third term is the purchases that represent the deviation from target inventory, $-\gamma_2\gamma_1(1-\pi)\varepsilon_t$. Since purchases are on credit, like sales, the cash flow associated with purchases differs from P_t. Assuming proportion β of the firm's purchases remains unpaid at the end of the period, AP_t is

$$\mathrm{AP}_t = \beta \mathrm{P}_t = \beta[(1-\pi)S_t + \gamma_1(1-\pi)\varepsilon_t - \gamma_1\gamma_2(1-\pi)\Delta\varepsilon_t]. \tag{5}$$

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

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

$$\mathrm{CF}_t = \pi S_t - [\alpha + (1-\pi)\gamma_1 - \beta(1-\pi)]\varepsilon_t + \gamma_1(1-\pi)[\beta + \gamma_2(1-\beta)]\Delta\varepsilon_t + \beta\gamma_1\gamma_2(1-\pi)\Delta\varepsilon_{t-1}. \tag{6}$$

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 Eq. (6) to show the earnings calculation is helpful:

$$E_t = \mathrm{CF}_t + [\alpha + (1-\pi)\gamma_1 - \beta(1-\pi)]\varepsilon_t - \gamma_1(1-\pi)[\beta + \gamma_2(1-\beta)]\Delta\varepsilon_t - \beta\gamma_1\gamma_2(1-\pi)\Delta\varepsilon_{t-1}. \tag{7}$$

If there are no accruals (sales and purchases are cash so $\alpha = \beta = 0$, and no inventory so $\gamma_1 = 0$), 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 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.[4]

The third and fourth terms are temporary cash flows due to the lagged adjustment of inventory and credit terms. Empirically, the coefficients of the differences in sales shocks in the third and fourth terms in Eq. (7) 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 throughout the text below. The empirical analysis and the tables include those terms and, for convenience, they are denoted θ_1 and θ_2. Ignoring θ_1 and θ_2, cash flow and earnings are parsimoniously given by

$$\mathrm{CF}_t = \pi S_t - \delta\varepsilon_t \tag{8}$$

and

$$E_t = \mathrm{CF}_t + \delta\varepsilon_t. \tag{9}$$

Current earnings is current cash flows adjusted by accruals. Since the accruals represent all the temporary cash flows, current earnings is a forecast of future cash flow.

2.2. Negative serial correlation in operating cash flow changes

The previous section notes that if the firm did not engage in credit transactions and carried no inventory, current cash flow 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 Eq. (8) that the change in cash flow for period t, $\Delta\mathrm{CF}_t$, is

$$\Delta\mathrm{CF}_t = \pi\varepsilon_t - \delta(\varepsilon_t - \varepsilon_{t-1}). \tag{10}$$

---

[4] The 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 et al., 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 $\alpha S_{t-1}/S_{t-1} = \alpha$.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 $\gamma_1(1-\pi)S_{t-1}/S_{t-1} = \gamma_1(1-\pi)$. Expected accounts payable as a fraction of expected sales is $\beta(1-\pi)S_{t-1}/S_{t-1} = \beta(1-\pi)$.

Given ε_t is serially uncorrelated, the $-\delta(\varepsilon_t - \varepsilon_{t-1})$ term in expression (10) is responsible for the serial correlation in cash flow changes. Formally, the serial correlation in cash flow changes is

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

The sign and magnitude of the correlation are a function of the relative magnitudes of the profit margin and the expected operating cash cycle expressed as a fraction of the year. Since π and δ are expected to be positive and the denominator in Eq. (11), $(\pi^2 + 2\delta^2 - 2\delta\pi)$ is always positive, $\rho\Delta CF_t, \Delta CF_{t-1}$ is negative so long as $\pi < \delta$, i.e., if the net margin is less than the operating cash cycle. Descriptive statistics reported in Section 3 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, $(\pi - 2\delta)\pi^2/(\pi^2 + 2\delta^2 - 2\delta\pi)$, 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.

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 Eq. (11), $\delta(\pi - \delta)$, will be positive, and the denominator of Eq. (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 $(\pi\varepsilon_t)$ in the current period and proportion α next period. Both periods' cash flows rise with the shock, so the serial correlation of the cash flow changes is positive.

To see the second effect, assume there is no profit, $\pi = 0$ in Eq. (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 0.23 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.

2.3. *Predicting future operating cash flows*

The best one-period-ahead forecast of CF_{t+1} from Eq. (8) is πS_t, which is identically equal to current earnings, E_t. The best forecasts for all future periods' cash flows are also E_t. This is not surprising. 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 inflows from sales. In essence, earnings undo the negative serial correlation in cash flow changes.

The forecast error for the best one-period-ahead forecast (i.e., for earnings) is $= \mathrm{CF}_{t+1} - E_t = \pi S_{t+1} - \delta\varepsilon_t - \pi S_t = (\pi - \delta)\varepsilon_{t+1}$, and its variance $[\sigma^2(FE_{t+1})]$ is

$$\sigma^2(FE_{t+1}) = (\pi - \delta)^2\sigma^2. \tag{12}$$

Using current operating cash flows to forecast one-period-ahead operating cash flows produces a larger forecast error than the forecast using earnings:

$$\sigma^2(\mathrm{FE}_{t+1}) = (\pi - \delta)^2\sigma^2 + \delta^2\sigma^2. \tag{13}$$

Compared to the forecast error variance using earnings as a forecast of future cash flows, the forecast error variance is higher using current cash flow 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 ($\delta\varepsilon_t$) due to the current sales shock. Because the forecast error variance using current cash flows includes the term, 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.

The empirical tests compare not only the accuracy of current earnings and cash flows themselves as forecasts of future cash flows, but also test the predictions using simple and multiple regressions. The regressions permit the cash flow forecasts to exploit the negative serial correlation in cash flows in forecasting future cash flows. The regressions thus avoid potential bias against current cash flows as forecasts of future cash flows.

2.4. Other time-series properties of earnings, operating cash flows and accruals

Serial correlation in accruals changes. The only accruals in the 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:

$$\begin{aligned} A_t &= \Delta AR_t + \Delta Inv_t - \Delta AP_t \\ &= [\alpha S_t + \gamma_1(1-\pi)S_1 - \beta P_1] \\ &\quad - [\alpha S_{t-1} + \gamma_1(1-\pi)S_{t-1} - \beta P_{t-1}]. \end{aligned} \tag{14}$$

Eq. (14) 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.[5] Thus, the accrual process, like the valuation capitalization process, captures future cash flow changes implied by the current cash flow changes.

Substituting δ in Eq. (14), accruals are

$$A_t = \delta\varepsilon_t. \tag{15}$$

The serial correlation in accrual changes is then

$$\rho\Delta A_t \Delta A_{t-1} = \frac{-\delta^2\sigma^2}{2\delta^2\sigma^2} = -0.5, \tag{16}$$

which is close to the average estimate of -0.44 obtained by Dechow (1994, Table 2). The serial correlation in accrual changes is independent of the α, β, and π parameters because, as seen from Eq. (15), 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 Eq. (15) for accruals with Eq. (8) for cash flows reveals that the $\delta\varepsilon_t$ term is common to both accruals and cash flows, but with opposite signs. Therefore, as noted previously, accruals 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 model are variable, earnings like sales follow a random walk:

$$E_t = E_{t-1} + \pi\varepsilon_t \tag{17}$$

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

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 a model 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. 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. The model produces this result.

Contemporaneous correlation between accrual and operating cash flow changes using expressions (15) and (8) (see Table 1) is

$$\rho\Delta A_t\Delta CF_t = \delta(\pi - 2\delta)/[2(\pi - 2\delta\pi + 2\delta^2)]^{0.5} \tag{18}$$

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 is obtained from expressions (17) and (8):

$$\rho\Delta CF_t\Delta E_t = (\pi - \delta)/(\pi^2 + 2\delta^2 - 2\delta\pi)^{0.5} \tag{19}$$

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 3.

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. Since $\delta > 0$ for most firms, the formulas for the correlations of future cash flows with both current accruals and earnings in Table 1 suggest positive correlation. And, as implied by the analysis in Section 2.3 both correlation formulas suggest the forecasting abilities of accruals and earnings are increasing in the cash operating cycle, δ.

2.5. Summary

A model of earnings, operating cash flows, and accruals developed in this section generates an explanation for the negative serial correlation in operating

Table 1

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

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

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 $\alpha_t = [(AR_t + AR_{t-1})/2Sales_t]$, $\beta_t = [(AP_t + AP_{t-1})/(2Sales_t * (1-\pi))]$, 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: $Inv_t = g_1\ Sales_t + g_2 \Delta Sales_t + err_t$, 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 $\theta_2 = \beta\gamma_1\gamma_2(1-\pi)$.

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 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.

3. Tests of relative forecast ability and correlation predictions

This section empirically examines the relative predictive abilities of earnings and operating cash flows to forecast future cash flows and compares the model's predicted correlation structure between cash flows, earnings, and accruals with the actual correlation structure using data for a large sample of firms.

We test whether earnings by itself is a better forecast of future operating cash flows than current operating cash flows by itself. Since this test does not require estimation of any parameters, all forecasts are out of sample. We also test whether the forecasting superiority of current earnings increases with the operating cash cycle, δ. We supplement these tests by regressing future cash flows on current cash flows and earnings. The regression tests permit cash flow forecasts to exploit the negative serial correlation in cash flows.

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. 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 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 descriptive statistics for serial- and cross-correlations 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 model (see Sections 4 and 5).

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

3.1. 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 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 because of the integral method of quarterly reporting (see Collins et al., 1984; Kross and Schroeder, 1990; Salamon and Stober, 1994; Rangan and Sloan, 1998). 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 (integral method of reporting). Modeling this process across quarters, like modeling seasonality, is likely to introduce considerable error into empirics.

The benefit from using quarterly data is that, ignoring the analytical and empirical issues, 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 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 left for future research.

We include firms with at least ten annual earnings, accruals, operating cash flow, and sales observations in first differences (i.e., 11 years of data) from 1963 to 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. The final sample consists of 22 776 first-difference observations on 1337 firms. The 11-year 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. The variable definitions are: E = earnings before extraordinary items and discontinued operations; CF = cash flow from operations, calculated as operating income before depreciation minus interest minus taxes minus changes in non-cash working capital; A = operating accruals, which are E-CF. Since some of the model parameter values are calculated as a fraction of sales, we also describe sales per share data.

The cash flow reported in the statement of cash flows required since 1987 by SFAS 95 is likely to have less measurement error than our calculated measure. But, its use would restrict our analysis to a period too short to perform time-series analysis, and so we do not use it. Operating cash flows calculated from fund from operations reported in the changes in financial position statement might also have less error. We do analyze data using this measure. Missing observations reduce the number of firms in our sample from 1337 to 667, but the tenor of the results is unchanged.

Operating accruals include accruals not incorporated in the 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 model is developed to provide intuitive insights into the relations between accruals, earnings, and cash flows. Empirical tests using accruals that go beyond the working capital accruals is an attempt to see if the model suffices in explaining observed correlations. Second, empirically depreciation accruals' inclusion or exclusion has very little effect on the time-series properties of first differences in accruals and on the results in the paper.[6] 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.

Table 2 reports descriptive statistics on earnings, cash flows, accruals, and sales, first differences in these variables, and variance of first differences in each. These are calculated using 1337 firm-specific average values for each variable, except in the case of variances.

Average earnings per share is \$1.13. Because non-cash expenses like depreciation and amortization reduce earnings, but not operating cash flow, the latter exceeds earnings. The difference between the two is accruals, which is on average -\$0.50 per share 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.

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

Table 2
Descriptive statistics on selected variables: Sample of 1,337 firms, data from 1963 to 1992

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 Δsales	1.19	2.85	− 8.66	− 0.40	0.74	2.17	20.74
Var (Δsales)	82.84	103.05	0.07	14.85	44.15	113.23	828.60

Sample: The sample consists of 22 776 observations on 1337 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 1337 firm-specific average values. Descriptive statistics for variances are based on a sample of 1337 variance observations for the sample firms. All numbers are in dollars per share.

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 assuming cross-sectional independence.[7] The reported serial correlations are adjusted for the small-sample bias [equal to $-1/(T-1)$, where T is the number of time-series observations] in their estimated values (Kendall, 1954; Ball and Watts, 1972; Jacob and Lys, 1995). 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 to sales,

[7] Since financial data are positively cross-correlated, the t-statistic is likely to be overstated.

Table 3
Descriptive statistics on model parameters: sample of 1337 firms, data from 1963 to 1992

Variable	Mean	Std. Dev.	Min	Q_1	Median	Q_3	Max
π	0.0495	0.0423	− 0.1435	0.0260	0.0426	0.0637	0.3508
α	0.15	0.08	0.00	0.11	0.15	0.18	1.32
β	0.07	0.04	0.01	0.05	0.06	0.08	0.64
γ_1	0.16	0.11	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	0.23	0.14	− 0.04	0.14	0.22	0.32	1.46
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 1337 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.

$\alpha_t = [(\mathrm{AR}_t + \mathrm{AR}_{t-1})/2\mathrm{Sales}_t]$,

$\beta_t = [(\mathrm{AP}_t + \mathrm{AP}_{t-1})/(2\mathrm{Sales}_t(1-\pi))]$,

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:

$\mathrm{Inv}_t = g_1\ \mathrm{Sales}_t + g_2\ \Delta\mathrm{Sales}_t + \mathrm{err}_t$, where Inv_t = inventory, Sales_t = sales during year t and $\gamma_1 = g_1/(1\text{-}\pi)$, 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.

averaged across the number years for which data are available for a firm. To calculate δ, θ_1, and θ_2 we define

$$\alpha_t = [(\mathrm{AR}_t + \mathrm{AR}_{t-1})/2\mathrm{Sales}_t],$$

$$\beta_t = [(\mathrm{AP}_t + \mathrm{AP}_{t-1})/(2\mathrm{Sales}_t(1-\pi)],$$

$$\pi_t = E_t/\mathrm{Sales}_t,$$

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

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

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 the firms' profitability. The inter-quartile range, however, is less than 4% (i.e., from 2.60% to 6.37%). The target operating cash cycle, δ, averages 0.23 for the sample firms. This means a typical firm's cash cycle is approximately 83 days. Most of this is due to investments in accounts receivables and inventories, which is seen from the average values of α of 0.15 and γ_1 of 0.07. Average values of θ_1 and θ_2 are close to zero, but θ_1 values are considerably dispersed.

3.2. 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, δ.[8] We expect earnings' superiority over cash flows to increase in the operating cycle. We report results using two tests. First, we use current earnings and operating cash flows themselves as forecasts of future operating cash flows. Second, we report results of firm-specific multiple regressions of future cash flows on current earnings and cash flows.

Table 4, panel A 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 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, standard deviations are relatively unaffected by the bias. Not surprisingly, we obtain similar results using earnings before depreciation to forecast 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 per share using earnings to forecast cash flows. The mean pairwise difference of \$0.29 per share, assuming independence, is statistically significant (t-statistic $= 17.87$). Two- and three-year-ahead forecast errors using

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

Table 4
Current operating cash flows and earnings as predictors of future cash flows

Panel A: Means of firm-specific standard deviations of forecast errors: Current operating cash flows and earnings as predictors of future cash flows Forecast (OCF_t) = OCF_{t-k} or E_{t-k}, $k = 1, 2$, or 3.

Sample	OCF_t forecasted using	Mean standard deviation	OCF_t forecasted 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

Panel B: Summary of firm-specific regressions of future cash flows on current cash flows and current earnings

$$OCF_{i,\,t+\tau} = \gamma_{i,0} + \gamma_{i,1} CF_{i,t} + \gamma_{i,2} E_{i,t} + \text{error}_{i,t+\tau}$$

Sample	Forecast horizon, τ years	γ_1 Mean	γ_1 t-statistic	γ_2 Mean	γ_2 t-statistic	Average adjusted R^2 in %
All	1	0.07	5.78	0.45	17.72	23.2
	2	− 0.03	− 2.19	0.45	14.21	11.1
	3	− 0.11	− 5.55	0.32	7.82	4.1
$Q1$	1	0.07	2.77	0.55	11.65	24.9
	2	− 0.07	− 2.13	0.57	9.24	11.9
	3	− 0.12	− 3.30	0.26	3.56	6.0
Q_2	1	0.09	3.37	0.47	9.94	21.2
	2	− 0.04	− 1.16	0.48	7.32	11.9
	3	− 0.07	− 1.74	0.25	2.79	2.9
Q_3	1	0.05	2.02	0.38	7.34	19.9
	2	− 0.06	− 2.20	0.38	5.79	9.6
	3	− 0.14	− 3.46	0.33	3.83	1.6
Q_4	1	0.09	3.29	0.39	6.91	27.0
	2	0.04	1.22	0.36	6.04	11.8
	3	− 0.11	− 2.57	0.46	5.61	5.8

Sample: The sample consists of 22 776 observations on 1337 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.

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.

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 0.05 level) for quartile 4 than quartile 1 at all forecast horizons. Given the number of possible comparisons, we note that the standard error for the differences is such that a difference of approximately 0.06 is required for significance and leave the reader to assess the significance of the differences of interest.

Regression results. Table 4, panel B, summarizes results of firm-specific multiple regressions of one-to-three-year-ahead cash flows on current cash flows and earnings. We report cross-sectional average coefficients from the firm-specific regressions for the entire sample and quartiles as in panel A. The results indicate that earnings are consistently incrementally useful in forecasting future cash flows at all horizons. Cash flows exhibit only modest incremental forecasting power, and the sign of their forecasting relation is not always positive or significant. This is seen, for example, from the results for the entire sample reported in the first three rows of panel B. In the one-year-ahead forecasting regressions (i.e., the first row), the cross-sectional average of the coefficient on operating cash flow is 0.07 with a t-statistic of 5.78, compared to the average coefficient of 0.45 with a t-statistic of 17.72 on earnings. Operating cash flow's relation with two- and three-year-ahead cash flows is negative as seen from the results in the second and third rows. In contrast, earnings continue to be positively related to future cash flows with a relatively small reduction in earnings' sensitivity to future cash flows as the horizon increases. Similar conclusions apply to the quartile results in panel B. In addition, unreported results from simple regressions of future cash flows individually on current cash flows and earnings yield conclusions that are similar to those from the multiple regression results discussed above.

Results in panels A and B together demonstrate that whether used alone or in conjunction with cash flows, earnings exhibit predictive power with respect to future cash flows. The regression results show that earnings' superiority does not stem from precluding cash flow changes to exploit their negative serial correlation. Since the difference between earnings and cash flows is accruals, earnings' forecasting power beyond cash flows is attributable to accruals.

3.3. 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 second column reports the predicted average correlation. To obtain the average, we first calculate the predicted correlation for each firm using firm-specific parameter values and the expressions in Table 1. The remaining columns report descriptive statistics for the empirically estimated correlations for the sample firms.

The average actual serial- and cross-correlations have the same sign as the predicted averages in four cases, while the magnitudes are close in five of the total seven cases. However, as discussed below, in all seven cases, assuming independence, a *t*-test of the difference between the predicted and actual average correlations rejects the null hypothesis of zero difference at the 1% alpha-level of significance. Given the number of observations and the independence assumption, this is not surprising.

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. The two correlations for which the difference between average predicted and actual correlations is large are both cross-correlations of earnings changes with cash flow changes. There is reason to believe that those correlations may be more susceptible to measurement error problems than the others in Table 5 (see below). Use of the cash flow measure calculated from funds from operations changes the estimated correlations in Table 5 very little, including the two earnings cross-correlations, so any measurement error problems also apply to that measure. The mean estimated cross-correlation between current earnings changes and future cash flow changes does change sign, from a significant −0.03 to an insignificant 0.002.

Average serial correlation in cash flow changes for the sample firms is predicted to be −0.35. The actual average value is −0.28 and the median is −0.29. Similarly, an average serial correlation of −0.41 is predicted for

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 model: sample of 1337 firms, data from 1963 to 1992

Correlation between	Predicted correlations using average parameter values	Actual correlations						
		Mean	Std. Dev	Min	$Q1$	Med	$Q3$	Max
ΔCF_t, ΔCF_{t-1}	− 0.35	− 0.28*	0.26	− 0.86	− 0.46	− 0.29	− 0.11	0.61
ΔA_t, ΔA_{t-1}	− 0.41	− 0.27*	0.26	− 0.84	− 0.46	− 0.29	− 0.09	0.74
ΔE_t, ΔE_{t-1}	0.00	− 0.02*	0.31	− 0.79	− 0.24	− 0.02	0.18	1.00
ΔA_t, ΔCF_t	− 0.92	− 0.88*	0.15	− 0.99	− 0.97	− 0.93	− 0.86	0.41
ΔE_t, ΔCF_t	− 0.40	0.15*	0.41	− 0.95	− 0.14	0.15	0.47	0.99
ΔA_t, ΔCF_{t+1}	0.46	0.31*	0.27	− 0.56	0.14	0.33	0.50	0.94
ΔE_t, ΔCF_{t+1}	0.61	− 0.03*	0.31	− 0.92	− 0.25	− 0.02	0.18	0.97

Sample: The sample consists of 22 776 observations on 1337 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 inventory model. The parameters and the predicted correlation are given in Table 1.

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.

*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.

accrual changes, compared to an actual average serial correlation of − 0.27. In both cases over three quarters of the firms in the sample have negative point serial correlation estimates. There is similar dispersion (standard deviation = 0.26) in the point estimates of the both serial correlations.

The 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, which is similar to that reported in Watts and Leftwich (1977, p. 261) and Dechow (1994, Table 2).

Dechow (1994) documents a negative contemporaneous association between accrual changes and cash flow changes. The model also predicts a strong negative association between accrual changes and cash flow changes. The predicted correlation is -0.92, 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.

As noted earlier in Section 2.4, 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 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.

One of the two large differences between average actual and predicted correlations is for the contemporaneous correlation between earnings changes and cash flow changes. The average predicted correlation is -0.40 versus an average actual correlation of 0.15. The predicted negative correlation is probably surprising to many.[9] Our model generates a negative correlation because changes in cash flows and accruals are negatively correlated. An increase in sales increases earnings, but tends to decrease cash flows and generates 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.

Fixed costs that do not vary with sales (see Section 4) 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.

The other large difference between average actual and predicted correlations is for current earnings changes and future cash flow changes. The average predicted correlation is 0.61 versus average actual correlation of -0.03. Inclusion of fixed costs will make the predicted correlation lower (and so closer to the average actual correlation) because the stationarity of fixed expenses will induce negative correlation in changes in fixed expenses.

[9] 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 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.

The lack of a significant association between current earnings changes and future cash flow changes is damaging to the model, but more importantly it is at odds with the results in Table 4. Recall that Table 4 presents results of regressions forecasting future cash flows using current cash flows and earnings. Earnings exhibit a consistently significant predictive ability. In light of those results, we find the failure of earnings changes to be associated with future operating cash flow changes puzzling. The presence of fixed costs and perhaps the following reason in part resolve the puzzle.

As mentioned above there is reason to believe that the estimated correlations between current earnings changes and current and future cash flow changes might be more influenced by measurement error than the other correlations we estimate. Our procedures for estimating operating cash flows and accruals are likely to induce measurement error in both those variables whether we calculate operating cash flows from earnings or from funds from operations. Any error in operating cash flows will induce an equal and offsetting error in accruals since accruals are estimated as earnings minus operating cash flows. Under the strong assumptions that the error is independent across time and independent of both cash flows and accruals, the effect is unclear on all the correlations listed in Table 5 except those involving earnings changes. The serial correlation in earnings changes is unaffected. The cross-correlations between current earnings changes and current and future cash flows are biased toward zero. Both average estimated correlations are relatively close to zero using both cash flow calculations. For all other correlations in Table 5, the numerator, the covariance, in the calculation is biased upward (downward) for correlations expected to be positive (negative) tending to move the correlation away from zero, but the denominator is biased upward moving the correlation toward zero. With the offsetting effects, the direction of the effect of measurement error on the estimated correlations is unclear.

3.4. Cross-sectional correlations

This section examines whether predicted firm and portfolio correlations are positively associated 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, firm-level estimates are noisy. Portfolio-level data can be effective in reducing noise. 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 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 the portfolios' actual with predicted correlations.

Second, we form industry portfolios. We believe using the two-digit SIC code industry classification as the grouping variable has desirable properties. There are 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. In this sense the grouping variable is correlated with the underlying true variables. Noise in the estimated parameters is rooted in the sample firms' ex post success and failure over the 20 or more years of historical period 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.[10]

Table 6 reports the results. Three of the six correlations between the predicted and actual values of firm-specific serial- and cross-correlations are significantly positive at the 0.05 level using 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 other three correlations are positive but 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 six correlations are positive, and three are significant at the 0.05 level. The absolute values of most of the correlations are high, but this is not surprising given the analysis is at the portfolio level.

[10] 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, while generally consistent with the results reported in the tables, are weaker than those reported in the paper. This might be due in part because the industry-level portfolios are dominated by extreme realizations of financial variables.

Table 6
Correlation between predicted and actual correlations at the firm level and portfolio level: Sample of 1337 firms, 20 portfolios formed on ranked predicted correlations and 59 portfolios representing 59 two-digit SIC code industries, data from 1963 to 1992

Correlation between	Correlation between predicted and actual correlations (p value)		
	Firm level	Portfolio by Predicted correlation	Portfolio by Industry
ΔCF_t, ΔCF_{t-1}	0.07 (0.01)	0.63 (0.00)	0.09 (0.24)
ΔA_t, ΔA_{t-1}	0.04 (0.09)	0.25 (0.14)	0.30 (0.01)
ΔE_t, ΔE_{t-1}	NA	NA	NA
ΔA_t, ΔCF_t	0.08 (0.00)	0.43 (0.03)	0.33 (0.01)
ΔE_t, ΔCF_t	0.15 (0.00)	0.89 (0.00)	0.42 (0.00)
ΔA_t, ΔCF_{t+1}	0.00 (0.50)	0.00 (0.50)	0.08 (0.29)
ΔE_t, ΔCF_{t+1}	0.02 (0.27)	0.10 (0.33)	0.06 (0.32)

Sample: The sample consists of 22776 observations on 1337 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 $E - \text{CF}$.
S = sales per share.
Δ is the first difference operator.
Portfolio by predicted correlation: 20 portfolios are formed by ranking sample firms according to their predicted correlations estimated using firm-specific parameters and the correlation formulas in Table 1. Portfolio predicted and actual correlations are simple averages of the component firm-specific predicted and actual correlations.
Portfolio by industry: Portfolios are defined using the two-digit SIC code classification. There are 59 industries. Portfolio predicted and actual correlations are simple averages of the component firm-specific predicted and actual correlations.
Probability levels are for one-sided tests.

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. Again all six correlations are positive and three are significant at the 0.05 level. Considering both the firm-level and portfolio-level analyses the correlation between predicted and actual correlations provides some support for the model.

4. Modifications to the model

This section enriches the model by introducing fixed costs. It 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 model a step closer to realistic corporate settings and also help explain some differences between actual and predicted correlations.

4.1. Fixed costs

The presence of fixed costs, including cash period costs and fixed selling and administrative costs, can potentially lead to a positive correlation between contemporaneous changes in earnings and cash flows, a negative correlation between earnings changes and future cash flow changes, and a small negative serial correlation in earnings changes. Fixed costs that do not vary with sales can generate all three correlations.[11] 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 over-differencing a stationary process. Fixed costs therefore induce negative serial correlation in earnings changes. Since fixed costs are both expenses and cash outflows, the negative serial correlation in their changes also induces negative correlation between current earnings changes and future cash flow changes.

An alternative, but not mutually exclusive, explanation for the negative serial correlation in earnings changes is errors in accrual forecasts (Ball and Watts, 1979; 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 equal the forecast. The error, however, is corrected next year and this correction generates the negative serial correlation in earnings.[12]

---

[11] In 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.

[12] To 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.

Other examples of accruals requiring forecasts (which are revised routinely) include: percentage completion of contracts; estimates of oil and gas reserves and their amortization; estimated cost of restoring stripped land in mining firms; amortization of mortgage fees based on mortgage prepayment estimates; 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.

Let fixed costs, a_t, 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), $m\sigma^2$.

4.2. Serial correlation in earnings changes

With the addition of fixed costs, earnings become

$$E_t = \pi S_t - a_t, \tag{20}$$

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

$$E_t = E_{t-1} + \pi\varepsilon_t - a_t + a_{t-1}. \tag{21}$$

The fixed costs generate negative serial correlation in earnings changes:

$$\rho \Delta E_t, \Delta E_{t-1} = -m/(\pi^2 + 2m). \tag{22}$$

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 5 for details).

4.3. Correlation between earnings changes and current and future cash flow changes

One consequence of fixed costs is that contemporaneous 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

$$\mathrm{CF}_t = \pi S_t - a_t - \delta\varepsilon_t. \tag{23}$$

The covariance between earnings changes and cash flow changes becomes

$$\mathrm{Cov}(\Delta E_t, \Delta \mathrm{CF}_t) = [\pi(\pi - \delta) + 2m]\sigma^2. \tag{24}$$

Therefore, if $2m + \pi^2$ exceeds $\pi\delta$, the contemporaneous covariance (and predicted correlation) between earnings changes and cash flow changes is positive.

Similarly, the covariance between the current earnings change and one-period-ahead cash flow change is

$$\mathrm{Cov}(\Delta E_t, \Delta \mathrm{CF}_{t+1}) = [\pi\delta - m]\sigma^2. \tag{25}$$

If m exceeds $\pi\delta$, the covariance (and the predicted correlation) between earnings changes and one-period-ahead cash flow changes is negative.

The predicted correlations using the fixed costs model with and without assuming $\theta_1 = \theta_2 = 0$, are listed in Table 7.

5. Tests of the modified model

This section examines whether predictions based on the modified model are in line with the actual correlations. We begin this section by briefly describing how we estimated the contribution margin and fixed costs. These are used in calculating predicted correlations.

5.1. 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

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

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

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

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 $(\mathrm{Sales}_t/\lambda_1) - \mathrm{Earnings}_t$. 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

Table 7

Predicted serial correlations and cross-correlations among cash flows, earnings, and accruals using the modified model with and without the assumption that $\theta_1 = \theta_2 = 0$. Profit margin, π, is measured as contribution margin, CM (see notes below).

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
$\Delta E_t, \Delta E_{t-1}$	$-m/(\pi^2+2m)$	$-m/(\pi^2+2m)$
$\Delta A_t, \Delta CF_t$	$\frac{\pi(\delta-\theta_1)-2\delta^2+6(\delta\theta_1-\theta_1^2-\theta_2^2)+8\theta_1\theta_2-2\delta\theta_2}{\{[\pi^2+2\delta^2-2\delta\pi+6\theta_1^2+6\theta_2^2-6\delta\theta_1+2\pi\theta_1-8\theta_1\theta_2+2\delta\theta_2+2m][2\delta^2-6\theta_1(\delta-\theta_1)+6\theta_2^2-8\theta_1\theta_2+2\delta\theta_2]\}^{0.5}}$	$\frac{(\pi-2\delta)}{[2(\pi^2-2\delta\pi+2\delta^2+2m)]^{0.5}}$
$\Delta E_t, \Delta CF_t$	$\frac{\pi-\delta+\theta_1+2m}{[\pi^2+2\delta^2-2\delta\pi+6\theta_1^2+6\theta_2^2-6\delta\theta_1+2\pi\theta_1-8\theta_1\theta_2+2\delta\theta_2]^{0.5}[\pi^2+2m]^{0.5}}$	$\frac{\pi(\pi-\delta)+2m}{[(\pi^2-2_\pi\delta+2\delta^2+2m)(\pi^2+2m)]^{0.5}}$
$\Delta A_t, \Delta CF_{t+1}$	$\frac{\delta^2-4\delta\theta_1+4\theta_1^2+3\delta\theta_2-7\theta_1\theta_2+4\theta_2^2}{\{[\pi^2+2\delta^2-2\delta\pi+6\theta_1^2+6\theta_2^2-6\delta\theta_1+2\pi\theta_1-8\theta_1\theta_2+2\delta\theta_2+2m][2\delta^2-6\theta_1(\delta-\theta_1)+6\theta_2^2-8\theta_1\theta_2+2\delta\theta_2]\}^{0.5}}$	$\delta/[2(\pi^2-2\delta\pi+2\delta^2+2m)]^{0.5}$
$\Delta E_t, \Delta CF_{t+1}$	$\frac{\pi(\delta-2\theta_1+_{\theta_2})-m}{[\pi^2+2\delta^2-2\delta\pi+2m+6\theta_1^2+6\theta_2^2-6\delta\theta_1+2\pi\theta_1-8\theta_1\theta_2+2\delta\theta_2]^{0.5}[\pi^2+2m]^{0.5}}$	$\frac{\pi\delta-m}{[(\pi^2-2_\pi\delta+2\delta^2+2m)(\pi^2+2m)]^{0.5}}$

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.
δ = target operating cash cycle $= \alpha_t + (1-\pi)\gamma_1 - \beta_t(1-\beta)$, where $\alpha_t = [(AR_t + AR_{t-1})/2Sales_t]$, $\beta_t = [(AP_t + AP_{t-1})/(2Sales_t(1-\pi))]$, 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:
$Inv_t = g_1\ Sales_t + \gamma_2 \Delta Sales_t + err_t$, 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 $\theta_2 = \beta\gamma_1\gamma_2(1-\pi)$. π = contribution margin on sales CM, 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 5.1 for details):
$Sales_t = \theta_0 + \theta_1\ Earnings_t + error_t$, where θ_0 is an estimate of FC/CM, where FC is fixed costs, and θ_1 is an estimate of 1/CM. Therefore, $FC_t = (Sales_t/\theta_1) - Earnings_t$. 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 to 1992

Variable	Mean	Std. Dev.	Min	Q_1	Median	Q_3	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 1337 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 5.1 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.

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, suggesting both true variation and estimation error. Because m and CM are not observable, we made simplifying assumptions in estimating these for individual firms. As a result, we suspect sampling errors heavily influence the cross-sectional variation in their estimates.

5.2. 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 expect the introduction of fixed costs to affect the predicted serial correlation in earnings changes and the predicted cross-correlations between earnings changes and contemporaneous and future cash flow changes. The fixed-cost model yields an average predicted negative serial correlation of − 0.30 for earnings changes. This is the same sign as the average estimated serial correlation, − 0.02, but the difference in magnitudes is large. Thus, the introduction of fixed costs does not satisfactorily model the autocorrelation in earnings changes.

The modification for fixed costs allows a positive correlation between contemporaneous earnings and cash flows and indeed the average predicted correlation is a positive 0.17. This is close to the actual average correlation of 0.15. The modification does not, however, predict a negative correlation between current earnings and future cash flows. The average predicted correlation does drop by more than half, from the variable-costs-only model's 0.61 to 0.25 with the modification, much closer to the average estimated correlation of -0.03.

Fixed costs have little effect on the other average predicted serial correlations. The one possible exception is the contemporaneous correlation between accrual changes and cash flow changes. The average predicted correlation increases from the variable-costs-only model's -0.92 to -0.63.

Overall, the actual correlations between changes in earnings, accruals, and operating cash flows have the signs predicted by the fixed cost model in six of the seven cases that we estimate. The effect of modifying the 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 for correlations involving earnings changes. So, while the modified model is helpful in explaining the average actual correlations among various variables, not all of its tests are predictive.

5.3. 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. For the fixed-cost model, at the firm level (fifth column of Table 9), six of the seven correlations are positive and significant at the 0.05 level. The sixth column of Table 9 reports the correlations for the 20 portfolios constructed using predicted correlations. All seven correlations are positive and six are significant at the 0.05 level. The industry portfolios (column seven) have five of seven correlations positive with three significant. Two correlations are negative and insignificant; those for current accruals changes and future cash flow changes and for serial correlation in earnings changes. For the modified model overall the cross-sectional correlation results provide some support for the model.

6. 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 how accruals offset the negative correlation in cash flow changes 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.

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 1337 firms, and 59 two-digit SIC code industries, data from 1963 to 1992

Correlation between	Model	Predicted correlations	Actual correlations	Correlation between predicted and actual correlations (*p*-value)		
				Firm level	Portfolio by predicted correlation	Portfolio by industry
ΔCF_t, ΔCF_{t-1}	W/o fixed costs	-0.35	− 0.28*	0.07 (0.01)	0.63 (0.00)	0.09 (0.24)
	Fixed costs	− 0.36		0.10 (0.00)	0.73 (0.00)	0.19 (0.07)
ΔA_t, ΔA_{t-1}	W/o fixed costs	− 0.40	− 0.27*	0.04 (0.09)	0.25 (0.14)	0.30 (0.01)
	Fixed costs	− 0.39		0.04 (0.09)	0.32 (0.08)	0.25 (0.03)
ΔE_t, ΔE_{t-1}	W/o fixed costs	0.00	− 0.02	NA	NA	NA
	Fixed costs	− 0.30		0.12 (0.00)	0.59 (0.00)	− 0.10(0.45)
ΔA_t, ΔCF_t	W/o fixed costs	− 0.92	− 0.88*	0.08 (0.00)	0.43 (0.03)	0.33 (0.01)
	Fixed costs	− 0.63		0.37 (0.00)	0.72 (0.00)	0.48 (0.00)
ΔE_t, ΔCF_t	W/o fixed costs	− 0.40	0.15*	0.15 (0.00)	0.89 (0.00)	0.42 (0.00)
	Fixed costs	0.17		0.04 (0.05)	0.46 (0.02)	0.35 (0.00)
ΔA_t, ΔCF_{t+1}	W/o fixed costs	0.46	0.31*	0.00 (0.50)	− 0.25 (0.29)	0.08 (0.29)
	Fixed costs	0.44		0.07 (0.02)	0.38 (0.05)	− 0.01 (0.46)
ΔE_t, ΔCF_{t+1}	W/o fixed costs	0.61	− 0.03	0.02 (0.27)	0.10 (0.33)	0.06 (0.32)
	Fixed costs	0.25		0.09 (0.00)	0.38 (0.05)	0.12 (0.19)

Sample: The sample consists of 22 776 observations on 1337 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.

*Significantly different from the predicted mean correlation at 1% significance level using a t-test for difference in means. Portfolio by predicted correlation: 20 portfolios are formed by ranking sample firms according to their predicted correlations estimated using firm-specific parameters and the correlation formulas in Table 1. Portfolio predicted and actual correlations are simple averages of the component firm-specific predicted and actual correlations.

Portfolio by industry: Portfolios are defined using the two-digit SIC code classification. There are 59 industries. Portfolio predicted and actual correlations are simple averages of the component firm-specific predicted and actual correlations.

Probability levels are for one-sided tests.

We test the predictions on a sample of 1337 firms. Current earnings are 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 (though they are significantly different). We also correlate the actual and predicted correlations at the firm and portfolio levels. The majority of correlations are significantly positive consistent with a relation between the actual and predicted correlations, but of relatively low magnitude.

Overall, the evidence suggests the model has some statistical explanatory power. In addition, the model 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.[13] A related line

[13] 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.

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.

Acknowledgements

We are grateful to Bill Beaver (the referee) and Ray Ball (the editor) for many constructive suggestions. We thank workshop participants at City University of Hong Kong, Cornell University, University of Colorado at Boulder, University of Minnesota, University of New South Wales, New York University, University of North Carolina, University of Quebec at Montreal and Stanford Summer camp for helpful comments. S.P. Kothari and Ross L. Watts acknowledge financial support from the Bradley Research Center at the Simon School, University of Rochester and the John M. Olin Foundation.

Appendix A. Inventory-level changes and sales changes

In this appendix we describe how we estimate the parameters of the model with inventory that is outlined in Section 2. 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:

$$\mathrm{INV}_t = \gamma_1 S_t + \gamma_2\, \Delta S_t + \mathrm{err}_t \tag{A.1}$$

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

References

Ball, R., Watts, R.L., 1972. Some time series properties of accounting income. Journal of Finance 27, 663–682.

Ball, R., Watts, R.L., 1979. Some additional evidence on survival biases. Journal of Finance 34, 197–206.

Beaver, W.H., 1989. Financial Accounting: an Accounting Revolution. Prentice-Hall, Englewood Cliffs, NJ.

Bernard, V.L., Stober, T.L., 1989. The nature and amount of information in cash flows and accruals. The Accounting Review 64, 624–652.

Brooks, L.D., Buckmaster, D.A., 1976. Further evidence of the time series properties of accounting income. Journal of Finance 31, 1359–1373.

Collins, W., Hopwood, W., McKeown, J., 1984. The predictability of interim earnings over alternative quarters. Journal of Accounting Research 22, 467–479.

Dechow, P.M., 1994. Accounting earnings and cash flows as measures of firm performance: The role of accounting accruals. Journal of Accounting and Economics 18, 3–42.

Finger, C., 1994. The ability of earnings to predict future earnings and cash flow. Journal of Accounting Research 32, 210–223.

Hayn, C., Watts, R.L., 1997. The difference in fourth quarter earnings. Working paper, University of Rochester.

Jacob, J., Lys, T., 1995. Determinants and implications of the serial correlation in analysts' earnings forecast errors. Working paper, Northwestern University.

Jones, J., 1991. Earnings management during important relief investigation. Journal of Accounting Research 29, 193–228.

Kendall, M.G., 1954. Note on bias in estimation of auto-correlation. Biometrika 41, 403–404.

Kross, W., Schroeder, D., 1990. An investigation of seasonality in stock price responses to quarterly earnings announcements. Journal of Business, Finance, and Accounting 16, 649–675.

Maddala, G.S., 1977. Econometrics. McGraw-Hill, Inc., New York, NY.

Maddala, G.S., 1988. Introduction to Econometrics. McMillan Publishing Company, New York, NY.

Ramakrishnan, R.T.S., Thomas, J.K., 1995. Valuation of permanent, transitory, and price-irrelevant components of reported earnings. Working paper, Columbia University.

Rangan, S., Sloan, R.G., 1998. Implications of the integral approach to quarterly reporting for the post-earnings-announcement drift. The Accounting Review 73, 353–371.

Ross, S.A., Westerfield, R.W., Jaffe, J.F., 1993. Corporate Finance, 3rd ed., Richard D. Irwin, Inc., Homewood, IL.

Salamon, G.L., Stober, T.L., 1994. Cross-quarter differences in stock price responses to earnings announcements: fourth-quarter and seasonality influences. Contemporary Accounting Research 11, 297–330.

Watts, R.L., 1977. Corporate financial statements, a product of market and political processes. Australian Journal of Management 2, 53–75.

Watts, R.L., Leftwich, R.W., 1977. The time series of annual accounting earnings. Journal of Accounting Research 15, 253–271.