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What Moves Investment Growth?

We use accounting identities to decompose unexpected changes in investment growth into surprises to current cash-flow growth and stock returns, and revisions of expectations about future cash-flow growth and future discount rates. Using a vector autoregressive model we find that current cash-flow surprises account for the largest element of the variance decomposition. Investment growth and current cash-flow surprises are negatively correlated with news about future cash-flow growth, which can be expected from persistent productivity shocks and decreasing returns to scale. We find little evidence of a discount rate channel for investment since return terms are small and have unintuitive signs.

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Business investment is perennially important for economics: it creates current employment and leads to long-run growth; at the same time large swings in investment are a primary contributor to business cycle volatility. Investment is a trade-off between the present and the future. When making investment decisions managers should consider the prospect of future profits created by the new investment and the present cost of such profits. But what really moves investment? Does the stock market affect investment over and above cash flows? Is investment explained by expected future profits or by current cash flows? These are some of the most fundamental questions in financial economics.

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Many papers study the relationship between investment, stock returns, and measures of "fundamentals" (see, e.g., Barro 1990, Morck, Shleifer, and Vishny 1990, Cochrane 1991, Blanchard, Rhee, and Summers 1993, Lamont 2000, Lettau and Ludvigson 2002, Campello and Graham 2013). While in general returns are found to have limited explanatory power for investment, a debate remains regarding the interpretation of this finding since it is hard to disentangle the effect of returns from the effect of cash flows. At the same time, economists have long been puzzled by a strong relation between investment and *current* cash flows (see Eisner 1978, for an early summary). Fazzari, Hubbard, and Petersen (1988) interpret this investment-cash flow sensitivity as evidence in favor of financial constraints, although others argue that current cash flow may contain long-run information not captured by other variables (see, e.g., Abel and Eberly 2011). The difficulty in this second strand of the literature is on how to separate information about long-run cash-flow dynamics from short-run cash-flow shocks.

Borrowing the asset pricing techniques developed by Campbell and Shiller (1988), we propose a simple methodology to address the above-mentioned issues, that is, the interplay between cash flows and returns, and between short-run and long-run dynamics. Our novel methodology has several advantages. First, investment growth in our framework is decomposed into four main elements—current cash flows, expectations of future cash flows, current returns, and expectations of future discount rates—through present-value identities before any theoretical consideration is brought to the table. Second, we estimate the relation between investment and each one of its four components simultaneously and within a consistent framework, allowing us to directly compare the relative *magnitudes* of the different elements. Finally, we allow for time variation in future discount rates, that is, for a discount rate channel, which as emphasized by Abel and Blanchard (1986) accounts for most of the movements in q (the present value of marginal profits) and potentially also for the movements in investment (see Lettau and Ludvigson 2002). It is important to emphasize that we decompose investment into its different elements, all of which are potentially endogenous and interact with each other. This is not the same as decomposing investment into its response to primitive drivers (e.g., technology or preference shocks). In other words, our decomposition accounts for the relative importance of the main channels of investment variation, but we do not claim that these elements *cause* investment in a deeper sense.

Specifically, we start from the intertemporal budget constraint of the firm that links cash flows, investment, equity values, and stock returns. The budget equation identifies the sources of variation in investment growth, but is model free in the sense that any theory that obeys basic identities can be expressed in this form. By being model free, our approach delivers a set of quantitative stylized facts for all potential theories to match. We can avoid taking a stand with respect to the underlying mechanisms because some basic relations—especially those enforced through accounting identities—must hold regardless of economic interpretation and modeling. The appeal of this approach can be summarized by going back to Brainard and Tobin (1968):

> We argue for the importance of explicit recognition of the essential interdependencies of markets in theoretical and empirical specifications of financial models. Failure to respect some elementary interrelationships–for example, those enforced by balance-sheet identities–can result in inadvertent but serious errors of econometric inference and of policy. This is true equally of equilibrium relationships and of dynamic models of the behavior of the system in disequilibrium. (p. 99)

We estimate current surprises and long-run news through a vector autoregressive (VAR) system in the style of variance decompositions that followed Campbell and Shiller (1988). This system of predictive regressions imposes minimal structure on expectations and on the information set available to economic agents when they make forecasts. Some of its advantages are, first, simplicity and the flexibility to condition on alternative information sets. Second, a predictive system instead of a single regression model has the advantage that all simultaneous effects, which can in principle offset each other, are accounted for. Chirinko and Schaller (1996) and Gatchev, Pulvino, and Tarhan (2010) make a similar point in favor of predictive systems vis-à-vis single equation models of investment. However, they do not compute long-run news terms like we do, and Gatchev, Pulvino, and Tarhan (2010) do not consider equity values as endogenous to the system. Third, predictive regressions provide estimates of short-run and long-run effects without relying on direct measures of q. Empirical proxies for q typically require particular modeling assumptions such as the equivalence theorem between average and marginal q (Hayashi 1982) and are prone to measurement error (see Erickson and Whited 2000, 2012). Much debate in the literature is focused on whether q fails as a sufficient statistic for long-run information, and on how cash-flow variables may contain long-run information that q does not capture (see Abel and Eberly 2011). Our measures sidestep this problem by computing long-run news that are based solely on identities and predictive regressions. To be sure, our methodology has its own shortcomings, but it represents a reasonable alternative way to estimate long-run information that is rooted in the asset pricing tradition.

Our main results refer to aggregate U.S. data starting from 1952, and industries of U.S.-listed firms starting from 1970. We also perform our decomposition at the firm level, although our framework is, admittedly, best suited to study investment series that are less lumpy. The main findings are as follows. First, the lion's share of variation in investment growth is strongly correlated with surprises to current cash-flow growth. Second, we find that investment growth is negatively correlated with news about long-run cash-flow growth, although this component is smaller than the one attributable to current cash-flow surprises. The differences in sign and magnitude reveal interesting dynamics in investment and cash flows that cannot be captured by a static model. In fact, we find that cash-flow surprises are not pure transitory windfalls, but they contain long-run information about future cash-flow growth. Finally, we find that, when compared to the magnitude of cash-flow terms, return terms are of second-order importance in accounting for investment dynamics, and crucially, they correlate with investment with unintuitive signs. Current return surprises are negatively correlated with investment growth as also found by Lamont (2000). More importantly, the correlation of investment growth and long-run discount rate news is positive, which is unintuitive in a present-value sense since it implies that investment growth increases when discount rates go up. One possibility is that positive discount rate news coincide with positive cash-flow surprises, and hence the correlation between investment and discount rate news that we can estimate empirically has the wrong sign. However, in the data, there is no such correlation between discount rate news and cash-flow surprises. Overall, we do not find evidence in favor of a discount rate channel.

We include a simple, stripped-down model where we derive some basic implications for the decomposition of investment growth. It is important to note that we focus on investment growth rather than investment levels (i.e., the investment-to-capital ratio). This has the advantage, empirically speaking, that first differences remove low-frequency aspects of the data (see Barro 1990, Cochrane 1991, and Morck, Shleifer, and Vishny 1990 along these lines). Investment growth is also the focus of an important part of the asset pricing literature on the cross-section of stock returns (see Titman, Wei, and Xie 2004, and Liu, Whited, and Zhang 2009 among others). Our model does surprisingly well in matching the positive covariance of investment and cash-flow surprises, and the negative covariance of investment with long-run cash-flow news. Persistent productivity shocks and decreasing returns to scale are two key features of the model that allow us to match these joint dynamics of cash flows and investment. It is important, in this respect, that we deal with growth rates and not with levels. Future investment *levels* are positively correlated to current (and persistent) productivity shocks, but future investment *growth rates* can be negatively correlated to current shocks because growth rates fall as the effect of the productivity shock decays into the future. The model with constant returns to scale does worse in matching these dynamics. However, the main problem with all versions of the model—with and without decreasing return to scale—is that they produce a counterfactually high comovement of investment and returns, and typically a strong negative effect of discount rates.

The model that we present allows us to digest the empirical results in an orderly fashion, making explicit the connection of cash flows, investment, and returns with primitive drivers such as technology or preference shocks. The different elements of the variance decomposition are endogenous in the sense that they all depend on the dynamics of these drivers. Admittedly, we cannot do justice to the richness and diversity of investment models. In particular, we do not claim that all investment theories and their multiple incarnations are beyond repair in their capacity to fit our empirical findings. We simply highlight where the main challenges lie in the data.

Our results are related to several strands of the literature. First, the large effect of current cash flows that we find is reminiscent of the investment-cash flow sensitivity literature started by Fazzari, Hubbard, and Petersen (1988). We emphasize that our results do not rely on assuming the existence of financial constraints, mispricing, managerial short-termism (excessive attention to stock markets) or myopia (insufficient attention to stock markets), or any other friction. Like Campbell and Shiller (1988) in the asset pricing literature, we solely rely on budget constraints that can be recast in terms of present-value relationships. We also find different responses of investment to short-run and long-run cash-flow terms, which highlights the fact that there are nontrivial dynamics between cash flows and investment that can go unnoticed in a purely static model. Our model tries to rationalize these patterns without assuming financial constraints, but we do not attempt to distinguish between models with and without financial constraints.

Second, our results are related to the long-standing debate about the relationship between stock markets and investment. Morck, Shleifer, and Vishny (1990) argue that the stock market is a side show for investment decisions. Blanchard, Rhee, and Summers (1993) arrive at a similar conclusion stating that "market valuation appears to play a limited role, given fundamentals, in the determination of investment decisions" (p. 132). Barro (1990), however, argues that returns have substantial explanatory power for investment growth, even in the presence of cash-flow variables. In this article, we find that, in general, returns play a secondary role in accounting for the variance of investment growth. Furthermore, when we split return information between short-run surprises and long-run discount rates we find that the discount rate channel is small in magnitude and goes in the wrong direction.

A related debate concerns the real effects of market inefficiency and mispricing (see, e.g., Chirinko and Schaller 1996, Stein 1996, Baker, Stein, and Wurgler 2003, Gilchrist, Himmelberg, and Huberman 2005, Polk and Sapienza 2009, Campello and Graham 2013). Our results suggest that the impact of market mispricing is at best limited, at least when studying aggregate investment, large portfolios of firms such as industries, or a long time series. The effects of mispricing are potentially easier to detect in narrow subsets of firms more exposed to stock market fluctuations (as, e.g., in Baker, Stein, and Wurgler 2003) or in particular time periods with notable deviations of prices from fundamentals (as in the 1990s technology bubble studied by Campello and Graham 2013).

The rest of the article proceeds as follows. Section 1 develops the present-value relationship between investment and discounted cash flows starting from the intertemporal budget constraint of the firm. Section 2 presents the various data sources and empirical methodology. Section 3 shows the results for aggregate investment growth and discusses portfolio- and firm-level results. Section 4 presents a simple log-linear model to digest the empirical findings. Section 5 concludes.

1. INVESTMENT AND THE PRESENT VALUE OF CASH FLOWS

1.1 The Firm's Intertemporal Budget Constraint

The intertemporal budget constraint for equity is

$$E_{t+1} = E_t \times R_{t+1} + NI_{t+1}^E - DIV_{t+1}, \tag{1}$$

where E_t is total equity value at the end of period t, R_t is gross equity return in period t, NI_t^E is net equity issuance in period t, and DIV_t is total dividends during period t. The difference $DIV_{t+1} - NI_{t+1}^E$ is net equity payout as in Boudoukh et al. (2007) or Larrain and Yogo (2008). Equation (1) says that equity in the current period is equal to equity last period, which has grown at the realized rate of return, plus the amount contributed by shareholders (i.e., net equity issuance), minus the dividend payout.

The Flow of Funds (FOF) identity is

$$I_{t+1} + DIV_{t+1} = EARN_{t+1} + CFADJ_{t+1} + NI^D_{t+1} + NI^E_{t+1}, \tag{2}$$

where I_{t+1} is investment, $EARN_{t+1}$ is earnings (after interest expense), $CFADJ_{t+1}$ is cash-flow adjustments to earnings, and NI^D_{t+1} is net debt issuance. Equation (2) states that the uses of funds (investment and payout) must be equal to the sources of the funds (cash flow plus net securities issuance).[1]

We define Y_{t+1} or *equity cash flow* as

$$\begin{aligned} Y_{t+1} &= EARN_{t+1} + CFADJ_{t+1} + NI^D_{t+1} \\ &= I_{t+1} + DIV_{t+1} - NI^E_{t+1}. \end{aligned} \tag{3}$$

The term "equity cash flow" is meant to refer to the total amount of cash that the firm can allocate to either investment or net equity payout. Combining equations (1) and (3) yields the intertemporal budget constraint for equity in terms of investment and equity cash flow:

$$E_{t+1} = E_t \times R_{t+1} + I_{t+1} - Y_{t+1}. \tag{4}$$

Similarly, we define Y^A_{t+1} or *asset cash flow* as

$$\begin{aligned} Y^A_{t+1} &= EARN_{t+1} + INT_{t+1} + CFADJ_{t+1} \\ &= I_{t+1} + DIV_{t+1} - NI^E_{t+1} + INT_{t+1} - NI^D_{t+1}, \end{aligned} \tag{5}$$

where INT_{t+1} is interest expense. Equation (5) shows that asset cash flow is the amount of cash the firm can allocate to either investment or net payout of equityholders and debtholders together. As in the case of equity, the intertemporal budget constraint for assets (equity plus debt) can be written as

$$A_{t+1} = A_t \times R^A_{t+1} + I_{t+1} - Y^A_{t+1}, \tag{6}$$

where A_t is the value of total assets (equity plus debt), R^A_{t+1} is asset return, and Y^A_{t+1} is asset cash flow.

The intertemporal constraints for equity and assets are very similar. We focus primarily on the one for equity because the connection between equity returns and investment has dominated much of the literature. The budget constraint for assets relates investment with returns that combine equity and debt. On the other hand, asset cash flow only captures internally generated funds, while equity cash flow includes

1. Appendix A provides additional details by relating our identities to the firm-level flow of fund identity discussed in Gatchev, Pulvino, and Tarhan (2010).

debt financing. Ultimately, the difference between both constraints is whether debt is included in returns (as in the case of assets) or in cash flows (as in the case of equity). Investment is the same in both cases.

1.2 Present-Value Relation Involving Cash Flow, Investment, and Discount Rates

In the same style of Campbell and Shiller (1988), we log-linearize the intertemporal budget constraint for equity in equation (4). The derivation for the case of total assets is analogous. In the following derivations, small letters represent the log of the original variables (in capital letters). The notation Δ_{t+1} refers to the log-difference between $t + 1$ and t for a given variable. As is explained in detail in Appendix B, the log-linearization of equation (4) gives us (ignoring constants):

$$v_t \approx r_{t+1} - \theta \Delta y_{t+1} + (\theta - 1)\Delta i_{t+1} + \rho v_{t+1}, \tag{7}$$

where we define,

$$v_t \equiv \theta y_t - (\theta - 1)\, i_t - e_t. \tag{8}$$

The variable v_t is the log version of the net payout yield for equity, which in levels is $(Y_t - I_t)/E_t$. Equation (7) is similar to equation (4) in Larrain and Yogo (2008); however, we dig deeper into the determinants of net payout growth in our specification. In Appendix B, we discuss the log-linearization in detail, including its accuracy, and the choice of parameters ($\theta = 1.77$ and $\rho = 0.99$).

Solving equation (7) forward and taking expectations, we get a present-value equation for the net payout ratio:

$$v_t = \sum_{j=1}^{\infty} \rho^{j-1} E_t[r_{t+j} - \theta \Delta y_{t+j} + (\theta - 1)\Delta i_{t+j}]. \tag{9}$$

The net payout ratio is higher because expected returns are higher, or expected cash-flow growth is lower, or expected investment growth is higher.

In a way analogous to the decomposition of unexpected returns of Campbell (1991), we decompose unexpected investment growth from equation (9) into four elements:

$$\Delta i_{t+1} - E_t \Delta i_{t+1} = \underbrace{-\frac{1}{\theta - 1}(r_{t+1} - E_t(r_{t+1}))}_{C_{r,t+1}} + \underbrace{\frac{\theta}{\theta - 1}(\Delta y_{t+1} - E_t(\Delta y_{t+1}))}_{C_{y,t+1}}$$
$$\underbrace{-\frac{1}{\theta - 1}\Delta E_{t+1}\sum_{j=2}^{\infty}\rho^{j-1} r_{t+j}}_{N_{r,t+1}}$$

$$+ \underbrace{\frac{\theta}{\theta - 1} \Delta E_{t+1} \sum_{j=2}^{\infty} \rho^{j-1} \Delta y_{t+j} - \Delta E_{t+1} \sum_{j=2}^{\infty} \rho^{j-1} \Delta i_{t+j}}_{N_{cf,t+1}}$$

$$= -C_{r,t+1} + C_{y,t+1} - N_{r,t+1} + N_{cf,t+1}. \tag{10}$$

The equation says that unexpected investment growth can be understood as the sum of four components: (i) unexpected current return ($C_{r,t+1}$), (ii) unexpected current cash-flow growth ($C_{y,t+1}$), (iii) discount rate news ($N_{r,t+1}$), and (iv) cash-flow news ($N_{cf,t+1}$). The first two components are current realizations that deviate from prior expectations. The last two components are revisions of expectations about the future. Equation (10) does not imply that the four right-hand-side elements *cause* investment growth. To the contrary, these are all potentially endogenous pieces that simply add up to total unexpected investment growth.

It is important to note that the investment decomposition holds by definition. Therefore, without resorting to any particular investment theory, one can see how each element contributes to investment. For example, holding constant current cash flow and expectations on future returns and cash flows, higher investment today must imply lower stock return today because of the substitution between investment and payout. This explains the negative sign before $C_{r,t+1}$. It does not mean, however, that unexpected investment and stock returns have to be negatively correlated in the data, because the other three terms can move around (or can be influenced by corporate policies) and affect investment at the same time. After these other effects are taken into account, investment and returns could be positively correlated.

Similarly, holding everything else constant, investment can be financed through a positive cash-flow shock, which explains the positive sign before $C_{y,t+1}$. This does not mean, however, that investment has to be positively correlated with cash-flow shocks. Forward-looking managers could react to a transitory cash-flow shock by adjusting current payout and leaving investment intact. That is, $C_{r,t+1}$ and $C_{y,t+1}$ can change at the same time without impacting investment.

We study the contribution to investment variation of each element by computing the covariance of $\Delta i_{t+1} - E_t \Delta i_{t+1}$ with each side of equation (10):

$$\begin{aligned} \text{var}(\Delta i_{t+1} - E_t \Delta i_{t+1}) &= \text{cov}(\Delta i_{t+1} - E_t \Delta i_{t+1}, -C_{r,t+1}) \\ &\quad + \text{cov}(\Delta i_{t+1} - E_t \Delta i_{t+1}, C_{y,t+1}) \\ &\quad + \text{cov}(\Delta i_{t+1} - E_t \Delta i_{t+1}, -N_{r,t+1}) \\ &\quad + \text{cov}(\Delta i_{t+1} - E_t \Delta i_{t+1}, N_{cf,t+1}). \end{aligned} \tag{11}$$

The variance of investment can be decomposed into four covariance terms. Intuitively, not all variation of the items in the right-hand side of equation (10) matters for the variation of investment. What matters is the portion of variation that is related to investment, which is precisely what the covariance captures.[2]

If we divide both sides of equation (11) by $\text{var}(\Delta i_{t+1} - E_t \Delta i_{t+1})$, we get

$$1 = \beta_{C_r} + \beta_{C_y} + \beta_{N_r} + \beta_{N_{cf}}, \tag{12}$$

where each β is a covariance divided by the variance of investment. Each β can be interpreted as the regression coefficient from running one of the terms, say $C_{r,t+1}$, on unexpected investment growth. In other words, if investment moves unexpectedly today this movement must come from either current returns, current cash flow, future returns, or future cash-flow growth. These regression coefficients have to add up to one if the budget constraint holds.

One can use this decomposition to give content to different theories about investment behavior. For example, if current shocks are purely transitory and managers are forward looking we expect to find small β_{C_r} and β_{C_y}, but large β_{N_r} and $\beta_{N_{cf}}$. Of course, the identity by itself cannot tell us about the relative importance of investment components. The economic content of the identity comes down entirely to estimation, which is what we do in the next section.

2. DATA AND EMPIRICAL METHODOLOGY

2.1 Data Sources

Our primary source for aggregate data is the seasonally adjusted quarterly data from the FOF Accounts of the United States, 1952:01–2014:04.[3] We construct the variables for the nonfinancial corporate sector. All flows are expressed at the quarterly frequency and not at the annual frequency. From table F.103, we obtain earnings ($EARN_t$, Line 1), dividends (DIV_t, Line 3), capital expenditure (I_t, Line 11) which includes fixed investment (Line 12) and inventory change, net equity issues (NI_t^E, Line 47), and net debt issues (NI_t^D, Line 40 plus Line 42). Interest expense (INT_t) is not reported by the FOF so we obtain it from the NIPA table 1.14. With these elements, we compute equity cash flow (Y_t) and asset cash flow (Y_t^A) as defined in equations (3) and (5), respectively. From table B.103, we obtain the book value of debt (Line 25) and the market value of equity (E_t, Line 41), which together represent our measure of total assets (A_t) as in Larrain and Yogo (2008). Stock returns (R_t) and asset returns (R_t^A) are computed with the above elements from equations (1) and (6), respectively. All data are deflated using the end-of-quarter CPI from the Bureau of Labor Statistics.

2. We emphasize that the four elements in the right-hand side of equation (10) are not assumed to be independent or orthogonal to each other. See Campbell and Ammer (1993) for a similar treatment regarding return decompositions.

3. Data were downloaded on December 2015 from http://www.federalreserve.gov/releases/z1/Current/data.htm.

Our secondary data source is a merge of the Compustat Annual Industrial File and the Center for Research in Security Prices (CRSP) Database. When constructing the variables, we follow the variable definitions and procedures in Larrain and Yogo (2008) and Gatchev, Pulvino, and Tarhan (2010) closely. Due to the requirement for the statement of cash flows, the data are available at annual frequency only since 1971 and up to 2014. We exclude SIC codes 6000–6799 to focus on the nonfinancial firms. The Compustat–CRSP data set covers only publicly traded companies, while the FOF includes public and private companies. From Compustat, we collect earnings (NI), dividends (DV), share repurchases (PRSTKC), and share issuance (SSTK). "Investment": is defined as capital expenditure (CAPX) minus the reduction in inventory (INVCH).[4] The market capitalization at the end of each year (E_t) and annual stock returns are computed using the CRSP database. Firm-level variables are aggregated to the market level. The main variables of interest during year t are then scaled with the total market capitalization at the end of year t. Individual stock returns (*ret*) and capital appreciation components (*retx*) are also aggregated to the market level using value weighting. Finally, annual log growth rate in variable X is computed as $\Delta x = \ln((\frac{X}{E})_t) - \ln((\frac{X}{E})_{t-1}) + \ln(1 + retx_t)$.

2.2 *Descriptive Analysis of Quarterly Sample*

Figure 1 plots investment growth against equity cash-flow growth (top) and earnings growth (bottom). Growth rates are computed as log differences. For visual clarity, we first compute the average across quarters in each year, and then plot the time series of annual averages. Investment growth tends to follow cash flow and earnings growth closely. For example, investment growth, cash-flow growth, and earnings growth reach their lowest points during the 2001 recession. Overall, investment growth and cash flow or earnings growth behave like close cousins (if not twins), going wildly up and down together.

Table 1 reports summary statistics for the quarterly sample. Average investment growth, earnings growth, and cash-flow growth are below 1%, and average stock returns are about 2% quarterly, which implies an average annual return of approximately 8%. Investment growth is about as volatile as stock returns, earnings growth, and cash-flow growth. The correlations of investment growth with cash-flow growth and with earnings growth are positive and high (0.72 and 0.47, respectively). These strong correlations are consistent with previous results in this literature (see Blanchard, Rhee, and Summers 1993, Hassett and Hubbard 1997, Caballero 1999). Dividend growth is less volatile than investment.[5] Dividend growth is essentially uncorrelated with either earnings growth or cash-flow growth.

4. In other words, the increase in inventory is categorized as investment. We do this in order to match the definition of capital expenditures in the FOF. This treatment, however, does not drive our results. We obtain very similar results using a definition of "investment" that excludes changes in inventory (see Section 3.2).

5. For this table, dividends are taken from Amit Goyal's database, and not from the FOF as in the rest of the article, in order to facilitate comparisons with the asset pricing literature. For details on the construction of variables in Amit Goyal's database, see Goyal and Welch (2008).

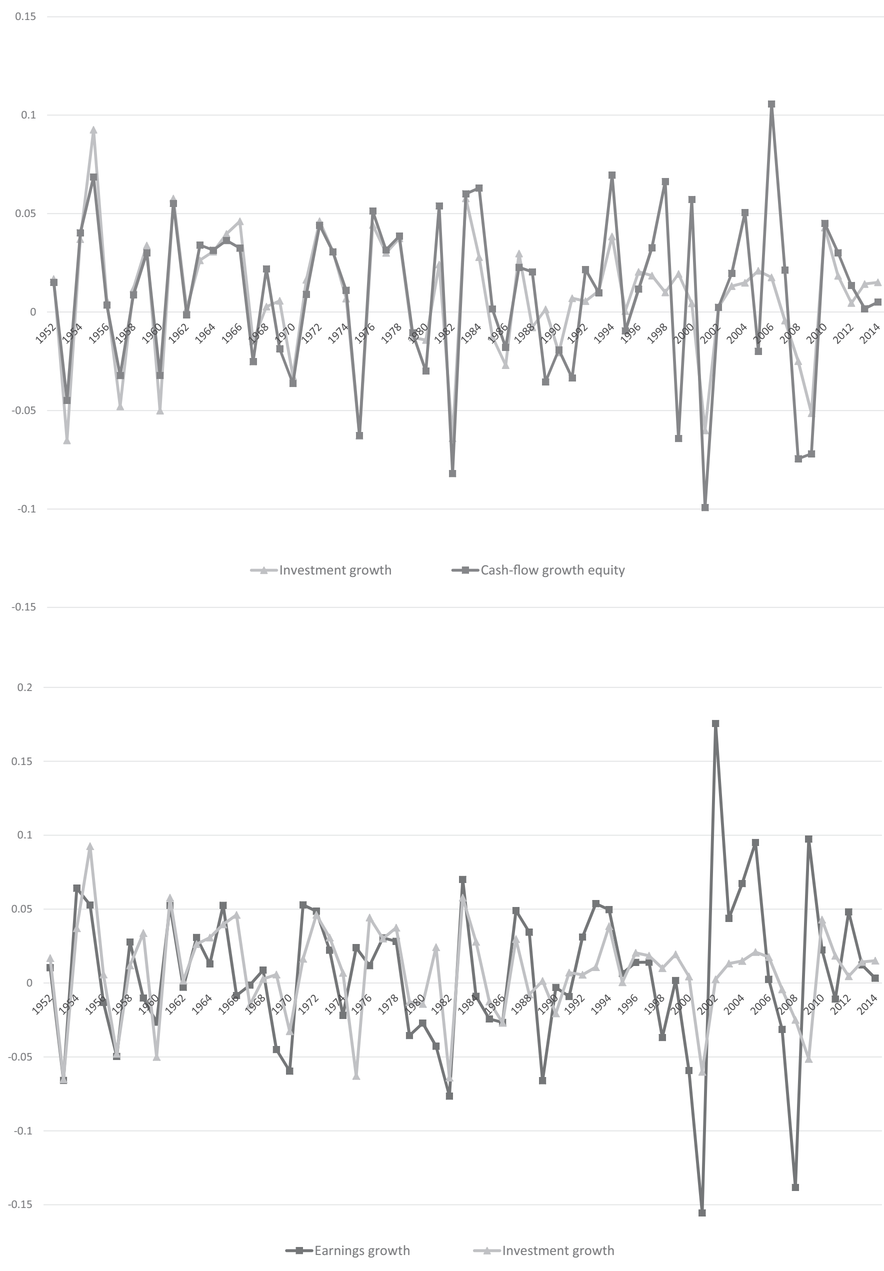

FIG. 1. Cash Flow and Investment Growth.

TABLE 1

Summary Statistics

Panel A: Summary stats

	Obs	Mean	Std. Dev.	Min	Max	First autocorr
Investment growth	251	0.008	0.068	−0.338	0.188	0.001
Returns equity	251	0.021	0.087	−0.313	0.214	0.074
Returns assets	251	0.016	0.047	−0.155	0.247	0.052
Cash-flow growth equity	251	0.009	0.093	−0.339	0.363	−0.120
Cash-flow growth assets	251	0.009	0.116	−0.392	0.337	−0.302
Earnings growth	251	0.006	0.085	−0.456	0.221	0.155
Dividend growth	252	0.005	0.019	−0.074	0.058	0.580
Net payout yield equity	252	0.010	0.005	0.001	0.030	0.823
Net payout yield assets	252	0.005	0.003	0.000	0.014	0.745
Dividend yield	252	0.008	0.003	0.003	0.016	0.972

Panel B: Correlation matrix

	Inv.	R. eq.	R. as	CF g. eq.	CF g. as.	Prof. g.	Div. g.	NP yield eq.	NP yield as.	Div. yield
Investment growth	1.00									
Returns equity	−0.04	1.00								
Returns assets	−0.05	0.95	1.00							
Cash-flow growth equity	0.72	−0.10	−0.07	1.00						
Cash-flow growth assets	0.64	−0.10	−0.07	0.85	1.00					
Earnings growth	0.47	−0.01	−0.01	0.34	0.35	1.00				
Dividend growth	0.11	0.03	0.07	0.13	0.10	−0.01	1.00			
Net payout yield equity	−0.07	−0.08	−0.06	0.14	0.11	−0.17	0.27	1.00		
Net payout yield assets	0.04	−0.09	−0.07	0.21	0.28	−0.05	0.29	0.83	1.00	
Dividend yield	−0.10	−0.13	−0.12	−0.07	−0.05	−0.13	−0.16	0.03	−0.16	1.00

Notes: Quarterly data 1952:01–2014:04. All data are taken from the FOF for the Nonfinancial Corporate Sector, except for dividend growth and dividend yield which are taken from Amit Goyal's database. Growth rates are computed as log differences and returns are in log form. The net payout yields and the dividend yield are in levels, not logs. All variables are expressed in real terms using the Consumer Price Index from the BLS.

Some correlations are puzzling. Stock returns are negatively related to investment growth (−0.04), although the correlation is small in magnitude. Lamont (2000) argues that this result is counterintuitive, since both investment and returns supposedly reflect the same forward-looking information. Lamont (2000) further argues that the lack of a proper correlation between investment and returns is caused by lags in the implementation of investment plans. Stock returns are also negatively correlated to cash-flow growth (−0.10) and earnings growth (−0.01). This seems to suggest that discount rates go up precisely when there are positive shocks to cash flows or earnings. As Kothari, Lewellen, and Warner (2006) point out, this would be against the predictions of standard asset pricing models.

The net payout yield for equity (i.e., $(Y_t - I_t)$ over E_t) is more stationary than the dividend yield, a variable that is commonly used to predict returns. The autocorrelation of net payout yield is 0.82, while the autocorrelation of the dividend yield is 0.97. In fact, the dividend yield exhibits a downward trend during much of the 1952–2014 period.

2.3 VAR Estimation of the Variance Decomposition

A direct approach for computing the variance decomposition is to run regressions of long-run returns or cash-flow growth onto current investment shocks. As seen in equation (12), the coefficients of these different regressions are interrelated and should add up to one. However, it has been documented that long-horizon regressions have poor finite-sample properties (e.g., Hodrick 1992, Valkanov 2003, Boudoukh et al. 2007). Therefore, we estimate expectations and surprises to the different variables through a VAR model as is typical in the asset pricing literature (e.g., Campbell 1991). Consider a vector of demeaned variables $x_t = (r_t, \Delta y_t, \Delta i_t, v_t)'$ such that:

$$x_{t+1} = \Phi x_t + \varepsilon_{t+1}, \tag{13}$$

where $E[\varepsilon_{t+1}] = 0$ and $E[\varepsilon_{t+1}\varepsilon'_{t+1}] = \Sigma$. The first three equations of this VAR can be interpreted as a vector error-correction model where the payout ratio v_t is the cointegrating vector. This is perhaps the best way to justify our VAR specification and thus the information set we use to estimate long-run news. As shown by Chen and Zhao (2009), changes in the VAR specification can lead to different conclusions about the importance of cash-flow news and return news when the information set is arbitrarily chosen, at least in the case of return decompositions. The forecasting variables typically used in investment regressions (e.g., Barro 1990) are precisely the ones we consider: investment lags, earnings or profitability growth, stock returns, and scaled stock prices (i.e., the net payout ratio). In robustness checks, we also include other variables (e.g., the market-to-book ratio) to the information set without any material impact on the results as we report later on.

The intertemporal budget constraint in equation (7) implies the following restriction on the VAR coefficients:

$$[e'_1 - \theta e'_2 + (\theta - 1)e'_3 + \rho e'_4]\Phi = e'_4, \tag{14}$$

where e_i is the ith column of the 4×4 identity matrix I. The VAR model implies that the dynamics of unexpected investment in equation (10) can be written as

$$\begin{aligned} e'_3\varepsilon_{t+1} = & \underbrace{-\frac{1}{\theta - 1}e'_1\varepsilon_{t+1}}_{C_{r,t+1}} + \underbrace{\frac{\theta}{\theta - 1}e'_2\varepsilon_{t+1}}_{C_{y,t+1}} \\ & \underbrace{- \frac{1}{\theta - 1}e'_1\rho\Phi(I - \rho\Phi)^{-1}\varepsilon_{t+1}}_{N_{r,t+1}} \\ & + \underbrace{\left(\frac{\theta}{\theta - 1}e'_2 - e'_3\right)\rho\Phi(I - \rho\Phi)^{-1}\varepsilon_{t+1}}_{N_{cf,t+1}}. \end{aligned} \tag{15}$$

Define

$$A = \rho\Phi(I - \rho\Phi)^{-1}. \tag{16}$$

The variance decomposition of unexpected investment becomes

$$\begin{aligned} e_3' \Sigma e_3 = &-\frac{1}{\theta - 1} e_1' \Sigma e_3 + \frac{\theta}{\theta - 1} e_2' \Sigma e_3 - \frac{1}{\theta - 1} e_1' A \Sigma e_3 \\ &+ \left(\frac{\theta}{\theta - 1} e_2' - e_3' \right) A \Sigma e_3. \end{aligned} \tag{17}$$

We estimate the VAR using OLS equation-by-equation. An alternative way, similar to what Campbell and Shiller (1988) do, is to obtain the coefficients of the fourth regression (the net payout yield regression) by imposing the constraints in equation (14). The unrestricted OLS regression for the net payout yield gives very similar coefficients, which only attests to the underlying connection between the different coefficients through a budget constraint and the accuracy of the log-linear approximation. The results of the variance decomposition are not affected in a material way by imposing the restrictions in equation (14). We report Newey–West corrected standard errors for the coefficients of the VAR.

3. RESULTS

3.1 Baseline Case with Aggregate Data

The left panel in Table 2 reports the VAR results using the quarterly sample for 1952:02–2014:04 and terms in the equity budget constraint. Consistent with the current literature (see Boudoukh et al. 2007, Larrain and Yogo 2008), the net payout yield significantly predicts stock returns (0.033, t-statistic 2.21). The payout yield also predicts cash-flow growth (−0.063, t-statistic −3.48) and investment growth (−0.043, t-statistic −3.46). Importantly, the ability of the payout yield to predict cash-flow growth and investment growth is stronger than its ability to predict returns; this is clear from both the size of the coefficients and the t-statistics. As in Lettau and Ludvigson (2002), we find that the same variables that predict returns also predict investment growth. Not surprisingly, the lagged payout ratio strongly predicts the current payout ratio (0.898, t-statistic 30.1).

As the cointegration vector, the ability of the net payout yield to predict each variable largely determines the long-run expectation of that variable. Since the payout yield is the key variable, one common practice in the literature is to estimate a reduced-form VAR, in which the only independent variable is the payout yield (see, among others, Cochrane 2008, Chen 2009). When we do so, the coefficient on the return equation becomes significant only at the 10% level (t-statistic 1.73), but the coefficient on the cash-flow equation (−0.076, t-statistic −4.27) and on the investment equation (−0.045, t-statistic −3.85) become slightly larger and more

TABLE 2

VAR RESULTS

Lagged regressor	Flow of funds quarterly 1952–2014 Dependent variable: Return equity	CF growth equity	Investment growth	Net payout yield	Compustat annual 1971–2014 Dependent variable: Return equity	CF growth equity	Investment growth	Net payout yield
Full VAR:								
Return equity	0.0900	0.0486	0.0939	−0.0743	0.053	0.299	0.269	0.270
	(1.458)	(0.535)	(1.593)	(−0.588)	(0.38)	(2.64)	(2.42)	(1.14)
Cash-flow growth equity	−0.0684	−0.275	0.0692	−0.472	0.469	0.768	0.610	0.400
	(−0.857)	(−2.396)	(1.363)	(−2.552)	(0.99)	(2.76)	(2.54)	(0.61)
Investment growth	−0.0445	0.352	−0.0692	0.724	−0.556	−0.721	−0.483	−0.344
	(−0.439)	(2.387)	(−0.546)	(3.709)	(−1.09)	(−2.20)	(−1.77)	(−0.42)
Net payout yield equity	0.0331	−0.0631	−0.0436	0.898	0.182	−0.098	−0.071	0.726
	(2.216)	(−3.482)	(−3.469)	(30.15)	(2.36)	(−1.41)	(−1.12)	(5.86)
Obs	250	250	250	250	42	42	42	42
R^2	3%	12%	7%	79%	13%	34%	27%	51%
Reduced VAR:								
Net payout yield equity	0.0268	−0.0761	−0.0456	0.883	0.165	−0.143	−0.104	0.687
	(1.738)	(−4.273)	(−3.854)	(29.70)	(2.64)	(−1.53)	(−1.37)	(5.28)
Obs	250	250	250	250	42	42	42	42
R^2	1%	8%	5%	78%	11%	14%	9%	49%

NOTES: Quarterly data (1952:02–2014:04) are obtained from the FOF for the Nonfinancial Corporate Sector. Annual data (1971–2014) are obtained from Compustat–CRSP merged database excluding financial firms. All variables are expressed in real terms using the Consumer Price Index from the BLS. Growth rates are computed as log differences and returns and the net payout yield are in log form. Newey–West t-statistics with four lags are reported in parenthesis below the coefficients. The log-linearization parameters are $\theta = 1.77$ and $\rho = 0.99$.

significant. In the language of cointegration, the results of the VAR can be summarized as follows. When the net payout ratio is high, and in order for the payout ratio to go back to its mean, it has to be the case that either future returns are high or future payout growth is low. The VAR shows that part of the adjustment is achieved through future returns, but more importantly through future payout growth.

These results are basically unchanged if we run a "kitchen-sink" VAR that includes a host of predictive variables studied in the literature and reviewed by Goyal and Welch (2008).[6] Adding more variables allows us to check the robustness of the predictive relationships to changes in the information set. In particular, the kitchen-sink VAR (not reported) includes the following variables besides those already presented in Table 2: the book-to-market ratio, the earnings-price ratio, the dividend-payout ratio, the term spread, the default yield spread, Lettau and Ludvigson's (2001) *cay*, inflation, net equity issuance, stock return variance, and the investment-to-capital ratio. We find that the predictive relationships presented in Table 2 are robust to including all or subsets of these variables.

The R^2 of the regressions in Table 2, though not very high, is on par with (or even better than) typical studies on return and cash-flow predictability (e.g., Campbell and Shiller 1988, Cochrane 2008). The R^2 for cash-flow growth and for investment growth of around 10% is actually quite good when compared to the literature. In the case of the kitchen-sink VAR, the R^2 goes up to approximately 25%.[7]

The right panel in Table 2 shows the annual VAR with aggregate Compustat–CRSP data. The main difference with the quarterly sample is that the power of the net payout yield to predict cash-flow growth and investment growth is reduced in significance. Different firms in Compustat are associated with different fiscal year ends, resulting in a nonsynchronicity problem that partially explains the reduction in significance. The R^2 for the cash-flow regression and investment regression is still higher than in the return regression since the other lags of returns, cash-flow growth, and investment growth provide substantial predictive power.

Table 3 reports the variance decompositions that follow from the quarterly VARs. In Panel A, we present the results for the full VAR, the reduced-form VAR, and the kitchen-sink VAR, all using the quarterly FOF data. For the full VAR, the variance of unexpected investment growth is 0.0041 per quarter, which implies a standard deviation of 6.4% per quarter. The standard deviation of raw investment growth is 6.8% per quarter (see Table 1). Therefore, raw investment volatility and unexpected investment volatility are quite close.

The covariance between unexpected investment growth and current cash-flow surprises is 0.0092 or 225% of the variance of unexpected investment growth. This number represents the largest element in the variance decomposition. In the lower

6. The predictive variables included in the kitchen-sink VAR are available from Amit Goyal's website, and they have been updated through to 2014.

7. Again, a limited predictive power is standard in regressions with growth rates. Very different are the regressions that use earnings and investment in levels (i.e., as fraction of assets), which tend to have higher R^2 because levels move more slowly. Regressions in levels also typically rely on cross-sectional differences and not solely on the time series like we do.

TABLE 3

VARIANCE DECOMPOSITION

Panel A: Quarterly FOF data: 1952:02–2014:04

	Full VAR		Reduced VAR		Kitchen-sink VAR	
	Levels	frac. of var(i)	Levels	frac. of var(i)	Levels	frac. of var(i)
var(i)	0.0041	1.00	0.0044	1.00	0.0037	1.00
Variance decomposition:						
cov(i, Cy)	0.0092	2.25	0.0096	2.17	0.0077	2.10
cov(i, Ncf)	−0.0035	−0.86	−0.0041	−0.94	−0.0035	−0.96
-cov(i, Cr)	0.0001	0.03	0.0001	0.02	0.0003	0.08
-cov(i, Nr)	−0.0017	−0.42	−0.0011	−0.25	−0.0009	−0.26
Sum	0.0041	1.00	0.0044	1.00	0.0035	0.96
Correlation(i, Cy)	0.7268		0.7047		0.6958	
Correlation(i, Cr)	−0.0175		−0.0116		−0.0435	
Correlation(Cy, Cr)	−0.0812		−0.0698		−0.1200	

Panel B: Annual Compustat data: 1972–2014

	Full VAR		Reduced VAR	
	Levels	frac. of var(i)	Levels	frac. of var(i)
var(i)	0.012	1.00	0.014	1.00
Variance decomposition:				
cov(i, Cy)	0.027	2.33	0.035	2.39
cov(i, Ncf)	−0.012	−1.02	−0.014	−0.96
-cov(i, Cr)	0.009	0.81	0.009	0.59
-cov(i, Nr)	−0.012	−1.04	−0.013	−0.93
Sum	0.013	1.087	0.016	1.087
Correlation(i, Cy)	0.9101		0.9252	
Correlation(i, Cr)	−0.3827		−0.2851	
Correlation(Cy, Cr)	−0.3471		−0.2346	

NOTES: We decompose the variance of unexpected investment growth (*i*) into covariances with each of its four components: (i) Cy: current cash-flow surprises, (ii) Ncf: future cash-flow news, (iii) Cr: current return surprises, and (iv) Nr: future discount rate news. The log-linearization parameters are $\theta = 1.77$ and $\rho = 0.99$. In Panel A, quarterly data are obtained from the FOF for the Nonfinancial Corporate Sector. The sample covers the period 1952:02–2014:04. In Panel B, annual data are obtained from Compustat–CRSP merged database excluding financial firms. The sample covers the period 1972–2014.

panel of the table, we report the correlation of investment surprises and cash-flow surprises, which is close to 0.70 in the three VAR specifications. Therefore, the high covariance is not simply an artifact of the volatility of cash flow, but it comes from the synchronization of unexpected movements in both investment and cash-flow growth. We obtain very similar results using both the reduced-form and the kitchen-sink VARs, suggesting that the results are not driven by potentially strange combinations of VAR coefficients, the autocorrelation of the variables, or the information set.

The second largest element (in absolute terms) in the decomposition is the covariance of long-run cash-flow growth and unexpected investment growth. The negative covariance implies that *higher* than expected current investment growth goes hand in hand with *lower* than expected long-run cash-flow growth. If we were to run a regression of long-run cash-flow growth on past investment surprises, we would get a *negative* coefficient (i.e., $\beta_{N_{cf}} < 0$). As explained in detail in Section 4, future cash-flow *growth* can be negatively correlated to the current increase in the capital stock as a product of diminishing returns in production.

The other two covariances—of unexpected investment growth with current return surprises and with discount rate news—are smaller in magnitude. The covariance with discount rate news is the largest of the two, but still smaller than 42% of investment variance. Return dynamics seem to be disconnected from investment growth or they are of second-order importance. Compared to Lamont (2000), we do not only estimate the covariance of current investment with current returns, but we simultaneously estimate the covariance of current investment with long-run discount rate news. In this last case, we also find a result that seems to defy the present-value logic: the positive covariance implies that investment growth increases when long-run discount rates go up.

Panel B in Table 3 shows the variance decomposition based on the annual Compustat–CRSP sample. Given the shorter sample length, we do not run the kitchen-sink VAR. The estimates of the cash-flow related terms are similar to the ones in the quarterly sample. The return-related terms are, however, larger than in the quarterly sample. Both terms are about 100% of investment variance in the case of the full VAR. Still, the covariance of investment and current returns is estimated to be negative, while the covariance of investment and discount rate news is positive. In a sense, the Compustat–CRSP results only deepen the puzzle.

3.2 Robustness Checks with Aggregate Data

We explore the robustness of our results to several modifications of the baseline framework. None of the modifications changes the overall picture.

Using earnings instead of cash flows. The difference between earnings and equity cash flow lies in the cash-flow adjustment term and net debt issuance (see equation (3)). Earnings growth and equity cash-flow growth have similar volatility and a relatively high correlation (0.34 in Table 1). Although the budget constraint of the firm does not hold exactly if we substitute equity cash flow for earnings, we run the basic VAR and decomposition using earnings growth instead of cash-flow growth.[8] The results in Table 4 are very similar to the baseline case, showing that the high covariance between investment and cash-flow growth is not an artifact of cash-flow adjustments or debt financing.

Asset decomposition. In Table 4, we present the decomposition of investment variance based on the budget constraint for total assets (equation (6)). The procedure is analogous to the case of equity, although using asset cash flow, asset returns, and the asset net payout yield (i.e., $(Y_t^A - I_t)$ over A_t). As seen in Table 1, asset cash-flow growth is slightly more volatile than equity cash-flow growth, but both are highly correlated (0.85). Similar to the case of equity, asset cash-flow growth is still highly

8. In this case, and the other cases in Table 4, we derive the coefficients on the net payout yield equation by imposing the restrictions in equation (14).

TABLE 4

Variance Decomposition: Other Cases

	Case II		Case III		Case IV	
	Levels	frac. of var(i)	Levels	frac. of var(i)	Levels	frac. of var(i)
var(i)	0.0039	1.00	0.0041	1.00	0.0005	1.00
Variance decomposition:						
cov(i, Cy)	0.0053	1.34	0.0096	2.36	0.0016	3.12
cov(i, Ncf)	−0.0016	−0.40	−0.0052	−1.29	−0.0004	−0.86
-cov(i, Cr)	0.0004	0.10	0.0002	0.05	−0.0001	−0.13
-cov(i, Nr)	−0.0001	−0.03	−0.0004	−0.10	−0.0006	−1.17
Sum	0.0040	1.01	0.0041	1.02	0.0005	0.96
Corr(i, Cy)	0.4536		0.6497		0.4515	
Corr(i, Cr)	−0.0557		−0.0565		0.0260	
Corr(Cy, Cr)	−0.0146		−0.0809		−0.0764	

Notes: The FOF data correspond to the Nonfinancial Corporate Sector. The quarterly sample covers the period 1952:02–2014:04. For Case II, we use earnings growth instead of equity cash-flow growth. For Case III, we use the asset budget constraint to derive the variance decomposition. For Case IV, we use fixed investment instead of capital expenditures. We decompose the variance of unexpected investment growth rate (i) into covariances with each of its four components: (i) Cy: current cash-flow surprises, (ii) Ncf: future cash-flow news, (iii) Cr: current return surprises, and (iv) Nr: future discount rate news. The log-linearization parameters are $\theta = 1.77$ and $\rho = 0.99$.

correlated with investment growth (0.64). Asset returns are lower on average than equity returns (1.6% vs. 2.1% quarterly), and less volatile (4.7% vs. 8.7% quarterly). The net payout yield for assets is also highly correlated with the net payout yield for equity (0.83).

The results in Table 4 show that the decomposition of investment growth based on the asset budget constraint is very similar. The covariance with cash-flow growth is still the largest term in the decomposition at 236% of investment variance. Long-run cash-flow growth is negatively correlated with current investment growth surprises. The covariances with current and long-run returns are both small: none is larger than 10% of investment variance in absolute value.

Fixed investment. In the last panel of Table 4, we use fixed investment instead of capital expenditures as our definition of "investment." The FOF defines capital expenditures as fixed investment plus inventory changes (plus other minor adjustments). Fixed investment accounts for the bulk of capital expenditures (95% on average), so we do not expect a big modification of our results by excluding inventory changes.[9] However, fixed investment is also more slow moving, that is, positively autocorrelated, and less volatile than inventory changes. Still, as seen in Table 4, the variance decomposition is very similar to our baseline case in Table 3. The sole exception is that the covariance of investment with discount rate news grows in magnitude to 117% of variance. This covariance remains positive, which, again, only deepens the puzzle.

9. By changing the definition of investment, we also change equity cash flow (Y_t) as seen in equation (3). Remember that equity cash flow is defined as the amount of cash that the firm can either invest or pay to shareholders. Another way to understand this is that now changes in inventory are included in $CFADJ_t$ in equation (2). Net equity payout ($DIV_t - NI_t^E$) does not change, hence, equity returns (R_t) and equity values (E_t) remain as in our baseline case.

TABLE 5

Variance Decomposition: Five terms

	Flow of funds (Full VAR) Quarterly 1952–2014		COMPUSTAT (Full VAR) Annual 1971–2014		COMPUSTAT (Fixed Inv) Annual 1971–2014	
	Levels	frac. of var(i)	Levels	frac. of var(i)	Levels	frac. of var(i)
var(i)	0.004	1.00	0.009	1.00	0.024	1.00
Variance decomposition:						
cov(i, earn)	0.005	1.26	0.027	3.15	0.070	2.97
cov(i, adj)	0.003	0.91	−0.009	−1.09	−0.031	−1.30
cov(i, Ncf)	−0.003	−0.76	−0.009	−1.08	−0.006	−0.24
-cov(i, r)	0.000	0.05	0.009	1.03	−0.001	−0.05
-cov(i, Nr)	−0.002	−0.46	−0.009	−1.02	−0.008	−0.34
Sum	0.004	1.00	0.008	0.99	0.025	1.04
Corr(i, earn)	0.430		0.405		0.587	
Corr(i, adj)	0.248		−0.142		−0.321	
Corr(i, r)	−0.027		−0.468		0.014	
Corr(earn, r)	0.001		0.204		0.250	
Corr(adj, r)	−0.079		−0.365		−0.342	

Notes: We decompose the variance of unexpected investment growth rate (i) into covariances with each of its five components: (i) earn: current earnings surprises, (ii) adj: current surprises about cash-flow adjustment, (iii) Ncf: future cash-flow news, (iv) Cr: current return surprises, and (v) Nr: future discount rate news. The FOF data correspond to the Nonfinancial Corporate Sector. The quarterly sample covers the period 1952:02–2014:04. Annual data are obtained from Compustat–CRSP merged database. The sample covers the period 1972–2014 and excludes financial firms. We define investment as capital expenditures except for the last panel where investment is just fixed investment. The log-linearization parameters are $\theta = 1.77$ and $\rho = 0.99$.

Five-term decomposition. We can write equity cash flow as

$$Y_{t+1} = EARN_{t+1}\left(1 + \frac{CFADJ_{t+1} + NI^D_{t+1}}{EARN_{t+1}}\right), \tag{18}$$

which after taking logs and first differences is

$$\Delta y_{t+1} = \Delta earn_{t+1} + \Delta adj_{t+1},$$

where $\Delta adj_{t+1} = \Delta \ln(1 + \frac{CFADJ_{t+1}+NI^D_{t+1}}{EARN_{t+1}})$. Therefore, equity cash-flow growth can be decomposed into earnings growth and the growth rate of the adjustment term defined above. Current cash-flow shocks in equation (10) can then be split into earnings shocks and adjustment shocks:

$$C_{y,t+1} = C_{earn,t+1} + C_{adj,t+1}. \tag{19}$$

In Table 5, we report the variance decomposition, now with five components, using the aggregate samples. The five-term decomposition is derived from a VAR with five variables $x_t = (r_t, \Delta earn_t, \Delta adj_t, \Delta i_t, v_t)'$. The covariance of investment growth and earnings growth still accounts for the largest share of the investment decomposition. Unexpected earnings growth and unexpected investment growth are positively correlated in the FOF and Compustat (the correlation coefficient is above 0.40). The covariance of investment growth and the adjustment term flips signs depending on whether we look at the FOF or Compustat–CRSP. A positive covariance, as seen in the FOF sample, implies that investment growth is unexpectedly high when the ratio of cash-flow adjustments and debt issuance to earnings is growing fast. In the Compustat–CRSP sample, we obtain a negative correlation instead.

Notice that the decompositions in the Compustat–CRSP sample give the same overall message regardless of whether we define "investment" as capital expenditures (fixed investment plus inventory change) or just fixed investment. The covariance of investment and earnings is still positive and the largest element in the decomposition, and the covariance of investment and discount rate news is still positive. The only difference is that fixed investment is less correlated with current returns since it moves more slowly than capital expenditures.

Notice that by adding the first two terms in the five-term decomposition we get approximately the term $\mathrm{cov}(\Delta i_{t+1} - E_t \Delta i_{t+1}, C_{y,t+1})$ of our original decomposition. The only difference lies in that the VAR for the five-term decomposition includes five variables instead of four, which modifies a bit the predictive power of each regression. Since the differences are small, and the five-term decomposition provides more information, we report only the five-term decomposition in the tables that follow.

3.3 Evidence with Disaggregated Data

Portfolio results. Table 6 reports the variance decomposition of unexpected investment growth for 10 industry portfolios formed with Compustat data. We used the Fama–French 10 industrial classifications. A first thing to note is that investment surprises are almost 10 times more volatile in the most volatile industry (consumer durables) compared to the least volatile industry (health care). Despite this variation in the level of investment variance, the composition of investment surprises is less heterogeneous across industries. The covariance with current cash-flow growth (earnings plus adjustment growth) is in general the largest element in the variance decomposition. On average, this covariance is about 200% of the variance of investment, confirming the main finding in the aggregate data. The covariance of unexpected investment growth with long-run cash-low news is always negative, but smaller in magnitude than the covariances in previous cases. The covariances of investment with return surprises and long-run discount rate news are generally smaller than other elements in the variance decomposition for each industry. The covariance of investment with long-run discount rate news is always positive, except for one industry (business equipment).

Firm-by-firm results. Applying our decomposition to individual firms presents some technical challenges. The most immediate problem is that some elements in the FOF identity in equation (4) can be negative in some periods, which makes it impossible to use logs. For instance, the fraction of firm-year observations with negative earnings in our Compustat sample is approximately 20%. Recall that the annual log growth rate in variable X is computed as $\Delta x = \ln((\frac{X}{E})_t) - \ln((\frac{X}{E})_{t-1}) + \ln(1 + retx_t)$. When X is negative, the log growth rate is undefined. To circumvent this problem, we increase both $(\frac{X}{E})_t$ and $(\frac{X}{E})_{t-1}$ by the same amount in those firm-year observations with negative Xs. To ensure the flow of fund identity, we apply the same constant upward

TABLE 6

VARIANCE DECOMPOSITION: INDUSTRY PORTFOLIOS

	Wholesale, Retail		Telcom		Energy		Others		Manufacturing	
	Level	Fraction	Level	Fraction	Level	Fraction	Level	Fraction	Level	Fraction
var(i)	0.015	1.00	0.052	1.00	0.054	1.00	0.012	1.00	0.026	1.00
cov(i, earn)	0.007	0.46	0.083	1.58	0.053	0.97	0.032	2.60	0.055	2.15
cov(i, adj)	0.015	1.02	0.032	0.61	0.046	0.85	−0.008	−0.67	−0.006	−0.23
cov(i, Ncf)	−0.007	−0.46	−0.042	−0.81	−0.042	−0.77	−0.005	−0.40	−0.014	−0.54
-cov(i, r)	0.008	0.56	0.004	0.08	0.008	0.15	0.001	0.06	0.009	0.34
-cov(i, Nr)	−0.009	−0.61	−0.025	−0.47	−0.011	−0.19	−0.007	−0.60	−0.018	−0.68

	Hi Tec Busi equipment		Utilities		Consumer nondurables		Consumer durables		Healthcare, Medi equip	
	Level	Fraction	Level	Fraction	Level	Fraction	Level	Fraction	Level	Fraction
var(i)	0.009	1.00	0.008	1.00	0.016	1.00	0.068	1.00	0.007	1.00
cov(i, earn)	0.064	6.86	0.007	0.80	−0.001	−0.03	−0.006	−0.09	0.041	5.81
cov(i, adj)	−0.048	−5.06	0.012	1.46	0.023	1.43	0.155	2.30	−0.023	−3.25
cov(i, Ncf)	−0.002	−0.26	−0.002	−0.28	−0.001	−0.05	−0.073	−1.08	−0.004	−0.56
-cov(i, r)	−0.005	−0.55	−0.002	−0.19	−0.001	−0.06	0.007	0.10	−0.004	−0.56
-cov(i, Nr)	0.001	0.14	−0.006	−0.74	−0.005	−0.28	−0.005	−0.08	−0.003	−0.39

NOTES: This table shows the variance decomposition results across industry portfolios. Annual data are obtained from COMPUSTAT-CRSP merged database. The sample covers the period 1972–2014 and excludes financial firms. We decompose the variance of unexpected investment growth rate (*i*) into covariances with each of its five components: (i) earn: current earnings surprises, (ii) adj: current surprises about cash-flow adjustment, (iii) Ncf: future cash-flow news, (iv) Cr: current return surprises, and (v) Nr: future discount rate news. We use the Fama–French ten industry classification. The log-linearization parameters are $\theta = 1.77$ and $\rho = 0.99$.

shift to investment (I), earnings ($EARN$), and equity cash flow (Y)—all scaled by market capitalization—so their minimum is 5%. This procedure, albeit *ad hoc*, avoids negative numbers and at the same time preserves the relative magnitudes of different growth rates.

Table 7 shows results for two different VARs using firm-by-firm data. First, we run a panel VAR that includes all the cross-sectional and time-series variation. Second, we run a VAR for each firm, and then we average coefficients and t-statistics across all firms for each variable (a "reverse" Fama–MacBeth procedure). For both VARs, we use the same panel containing firms with at least 18 years of data. The panel contains 2,167 firms, each with an average of 28 years of data.

The magnitude of coefficients is similar across both VARs (see Panels A1 and B1). The main predictive relationships observed in the aggregate data are also seen here. For example, the net payout ratio predicts returns with a positive sign, and earnings and investment growth with a negative sign. The autocorrelation coefficient of the net payout yield is smaller than at the aggregate level (e.g., 0.44 in the panel VAR). The R^2 is higher than in the case of aggregate data, but still only around 30% at the most.

The results for the variance decomposition in Panels A2 and B2 show that investment is naturally more volatile at the firm level than at the aggregate level or industry level. Current earnings growth accounts for close to 100% the variation in investment, while the other elements of the variance are quite small. Both cash-flow news and discount rate news seem practically irrelevant at the firm level.

3.4 Do Cash-Flow Surprises Contain Long-Run Information?

Our findings show that cash-flow surprises account for the lion's share of variation in unexpected investment growth. Therefore, a natural question to ask is whether these shocks are transitory surprises or if they represent signals about the future. This is important since in many models cash-flow surprises affect investment because they are signals about future profitability (e.g., Abel and Eberly 2011). In terms of our previous notation, this question boils down to estimating the covariances between cash-flow surprises and news terms, that is, $\text{cov}(C_{y,t+1}, N_{cf,t+1})$ and $\text{cov}(C_{y,t+1}, N_{r,t+1})$. Remember that the four terms in the decomposition shown in equation (10) are not assumed to be orthogonal, hence these covariances can be positive, negative, or zero. Intuitively one can understand these covariances as coming from predictive regressions of future long-run cash-flow growth or returns on current cash-flow surprises:

$$\sum_{j=2}^{T} \Delta y_{t+j} = a + bC_{y,t+1} + \epsilon,$$

$$\sum_{j=2}^{T} r_{t+j} = c + dC_{y,t+1} + \varepsilon.$$

TABLE 7

Variance Decomposition: Individual Firms

Panel A1: Panel VAR

	Dependent variable				
Lagged regressor	Return	Earnings growth	CF adj growth	Investment growth	Net payout yield
Return	−0.007	0.464	−0.340	0.301	−0.228
	(−1.08)	(36.13)	(−27.24)	(37.05)	(−12.77)
Earnings growth	−0.003	−0.330	0.244	0.138	−0.543
	(−0.50)	(−33.99)	(26.47)	(21.03)	(−36.05)
Adjustment growth	−0.007	0.083	−0.221	0.102	−0.622
	(−1.43)	(9.72)	(−26.18)	(17.47)	(−43.10)
Investment growth	−0.029	−0.080	−0.076	−0.433	0.437
	(−5.60)	(−8.59)	(−7.60)	(−56.09)	(29.35)
Net payout yield	0.011	−0.075	−0.163	−0.082	0.449
	(6.00)	(−20.24)	(−43.89)	(−37.91)	(69.21)
Obs	59,653	59,653	59,653	59,653	59,653
No. of firms	2,167	2,167	2,167	2,167	2,167
R^2	0%	11%	21%	13%	17%

Panel A2: Variance decomposition

	Levels	frac of var(i)
var(i)	0.302	1.00
cov(i, earn)	0.329	1.09
cov(i, adj)	0.027	0.09
cov(i,Ncf)	0.006	0.02
-cov(i, r)	−0.058	−0.19
-cov(i, Nr)	0.005	0.02

Panel B1: Firm-by-firm VAR

	Dependent variable				
Lagged regressor	Return	Earnings growth	CF adj growth	Investment growth	Net payout yield
Return	0.013	0.474	−0.385	0.285	−0.320
	(1.35)	(22.33)	(−18.94)	(22.64)	(−12.79)
Earnings growth	0.006	−0.313	0.407	0.224	−0.176
	(0.57)	(−14.06)	(17.84)	(14.68)	(−7.22)
Adjustment growth	−0.036	0.040	−0.031	0.139	−0.219
	(−3.76)	(2.05)	(−1.62)	(10.00)	(−11.46)
Investment growth	−0.032	−0.070	−0.162	−0.401	0.141
	(−2.56)	(−2.65)	(−6.32)	(−26.21)	(5.50)
Net payout yield	0.037	−0.076	−0.221	−0.103	0.282
	(13.05)	(−14.38)	(−40.82)	(−25.70)	(35.59)
Average no. of periods	28	28	28	28	28
No. of firms	2,167	2,167	2,167	2,167	2,167
R^2	22%	27%	37%	30%	31%

Panel B2: Variance decomposition

	Levels	frac of var(i)
var(i)	0.250	1.00
cov(i, earn)	0.298	1.17
cov(i, adj)	−0.002	−0.06

(*Continued*)

TABLE 7

CONTINUED

Panel B2: Variance decomposition

	Levels	frac of var(i)
cov(i,Ncf)	0.012	0.16
-cov(i, r)	−0.051	−0.21
-cov(i, Nr)	−0.001	−0.03

NOTES: We show results for two different VARs using firm level data. Annual data are obtained from Compustat–CRSP merged database. The sample covers the period 1972–2014 and excludes financial firms. We include firms with at least 18 years of data. The panel contains 2,167 firms, each with an average of 28 years of data. In Panel A1, we run a panel VAR that includes all the cross-sectional and time-series variations. In Panel B1, we run the VAR for each firm, and then average coefficients and *t*-statistics across all firms for each variable. In Panels A2 and B2, we decompose the variance of unexpected investment growth rate (i) into covariances with each of its five components: (i) earn: current earnings surprises, (ii) adj: current surprises about cash-flow adjustment, (iii) Ncf: future cash-flow news, (iv) Cr: current return surprises, and (v) Nr: future discount rate news. The log-linearization parameters are $\theta = 1.77$ and $\rho = 0.99$.

TABLE 8

PREDICTIVE POWER OF CURRENT EARNINGS SHOCKS

Panel A: Flow of Funds data

Future horizon (quarter)	1	2	3	4	8	12
Cash-flow growth equity	−0.191	−0.189	−0.278	−0.253	−0.534	−0.619
	(−2.075)	(−2.499)	(−2.688)	(−2.044)	(−4.367)	(−4.427)
Net cash-flow growth equity	−0.498	−0.486	−0.701	−0.554	−1.182	−1.307
	(−2.257)	(−2.832)	(−3.019)	(−2.163)	(−4.980)	(−4.783)
Earnings growth	−0.0715	−0.157	−0.165	−0.366	−0.648	−0.875
	(−1.261)	(−1.335)	(−0.972)	(−2.282)	(−2.729)	(−4.027)
Returns	−0.0517	−0.00976	−0.0258	0.0585	0.154	0.234
	(−0.860)	(−0.0908)	(−0.195)	(0.486)	(0.859)	(0.910)

Panel B: Compustat data

Future horizon (year)	1	2	3	4	5	6
Cash-flow growth equity	−0.302	−0.452	−0.357	−0.698	−0.805	−0.941
	(−1.556)	(−1.543)	(−1.419)	(−2.894)	(−2.403)	(−4.175)
Net cash-flow growth equity	−0.692	−1.036	−0.828	−1.486	−1.767	−1.987
	(−1.805)	(−1.870)	(−1.905)	(−3.368)	(−2.931)	(−3.899)
Earnings growth	−0.385	−0.555	−0.554	−1.740	−1.744	−1.723
	(−0.851)	(−0.919)	(−0.661)	(−2.988)	(−2.389)	(−2.568)
Returns	0.627	0.808	0.603	0.610	0.299	0.251
	(2.695)	(2.827)	(1.370)	(1.430)	(0.830)	(0.430)

NOTES: We regress long-run (accumulated) cash-flow growth, investment growth, earnings growth, and returns on lagged earnings surprises (VAR residuals from VARs in Table 3). Net cash-flow growth is defined as $(\theta/(\theta - 1))$*earnings growth-investment growth. Newey–West *t*-stats are reported. Sample period is 1952:02–2014:04 for FOF data and 1972–2014 for Compustat data.

While we can also estimate the covariances of interest directly from the VAR, the predictive regressions are more intuitive and they show that the results do not rely on a particular VAR structure.

Panel A of Table 8 reports results for long-horizon regressions in the FOF quarterly sample. A positive surprise to cash-flow growth is a strong predictor of future lower cash-flow growth at least up to 12 quarters after the shock. The effects are long lasting and do not correspond simply to short-run mean reversion. The same predictive power is seen in net cash-flow growth, which following the logic of cash-flow news in equation (10) is defined as $[\theta/(\theta-1)]\Delta y_t - \Delta i_t$. cash-flow surprises have no predictive power for returns at any horizon. Panel B of Table 8 shows similar results using the aggregate Compustat–CRSP annual sample. The negative relationship between current cash-flow surprises and future cash-flow growth appears with all alternative measures of cash flow. There is some predictive power for returns in the short term, but no predictive power in the long term as in the FOF sample.

We conclude that cash-flow shocks contain long-run information. However, these shocks have predictive power for future cash-flow growth, but not for discount rates. Considering long horizons we can say that a positive cash-flow surprise implies *lower* future cash-flow growth, that is, $\text{cov}(C_{y,t+1}, N_{cf,t+1}) < 0$, although no change in discount rates, that is, $\text{cov}(C_{y,t+1}, N_{r,t+1}) \approx 0$.

These regressions help us to complete the picture, although they only reiterate our previous findings. If the argument is that current cash-flow surprises are correlated with investment growth because current cash flow say something about the future, then that forward looking component of investment is already captured by the terms $\text{cov}(\Delta i_{t+1} - E_t \Delta i_{t+1}, N_{cf,t+1})$ and $\text{cov}(\Delta i_{t+1} - E_t \Delta i_{t+1}, -N_{r,t+1})$ in our decomposition. The advantage of estimating all the pieces of the identity together is precisely to impose discipline on the stories one can tell about the different factors that move investment.

3.5 Investment Lags

Lamont (2000) argues that although investment and returns respond to the same forward-looking information, investment decisions are implemented with lags while prices reflect the information instantaneously. This can in principle explain the puzzling negative correlation between investment and return surprises. Consistent with this argument, Lamont (2000) shows that investment plans (rather than actual investment) and returns are positively correlated. Similarly, Lettau and Ludvigson (2002) show that some financial variables that predict returns also predict investment in the long run, although not in the short run.

Can investment lags explain (i) the strong correlation between investment shocks and current cash-flow surprises, and (ii) the wrong sign in the correlation of investment shocks and return surprises? The answer to the first question is likely no. This is because, contrary to the existence of lags, the response of investment to current cash-flow shocks is not delayed. The fact that current cash-flow shocks are strongly related to investment suggests that the bulk of investment is not implemented with lags.

Investment lags have more potential to answer the second question, that is, the disconnection that we observe between investment and stock returns. We explore this issue in Table 9 where we regress future investment growth on lagged return surprises. Consistent with investment lags, returns predict two- and three-quarter ahead investment growth with the correct (positive) sign. After three quarters the predictive power disappears.

The predictive power is, however, quite small. The R^2 (the fraction of future investment variance explained by the variable) is at best 5% in these regressions. Therefore, even if investment lags can save the role of returns, they still do not

TABLE 9

Regressions of Future Unexpected Investment Growth

F.i	Cr	R^2	Cr	F.Cy	R^2
1	−0.00951	0.000	−0.00189	0.232	0.518
	(−0.265)		(−0.0754)	(16.27)	
2	0.121	0.046	0.0298	0.227	0.522
	(3.463)		(1.172)	(15.63)	
3	0.101	0.033	0.0388	0.227	0.524
	(2.877)		(1.547)	(15.89)	
4	0.0171	0.001	0.0239	0.231	0.521
	(0.477)		(0.959)	(16.24)	
5	0.0260	0.002	0.0119	0.230	0.520
	(0.723)		(0.478)	(16.16)	
8	−0.00330	0.000	−0.00477	0.225	0.513
	(−0.0934)		(−0.193)	(15.88)	

Notes: We regress future unexpected investment growth (F.i) on current Cr (current return surprise). Unexpected investment growth is measured at least one quarter, and up to eight quarters, after Cr. In the right-hand side panel, we also control for Cy (current earnings surprise) during the same quarter of unexpected investment growth. The FOF sample covers the period 1952:02–2014:04. *t*-Statistics are reported below the coefficients.

explain the bulk of investment variation. This is because most of investment variation corresponds to a simultaneous response—without a lag—to cash-flow shocks. In particular, the right-hand side panel in Table 9 shows that the R^2 increases up to about 50% when contemporaneous cash-flow shocks are included in each regression. Contemporaneous cash-flow shocks also seem to reduce the predictive power of past returns.

4. UNDERSTANDING THE VARIANCE DECOMPOSITION OF INVESTMENT GROWTH WITH A SIMPLE MODEL

Having summarized the empirical patterns regarding the variance decomposition of investment growth, in this section we explore whether these patterns can be understood in a simple model.

4.1 Production and Capital Accumulation

Assume that there is a single good in the economy. Earnings can be used for consumption or for investment, which increases the stock of capital next period. Assume that earnings (Y_{t+1}), productivity (Z_{t+1}), and the capital stock (K_{t+1}) are related through a Cobb–Douglas production function:[10]

$$Y_{t+1} = Z_{t+1} K_{t+1}^{\alpha}. \tag{20}$$

10. One can also understand this production function as having fixed unit labor. We express the production function in terms of earnings and not output, but since we later on work with logs and abstracting from constants, this is irrelevant. In a Cobb–Douglas framework, earnings (output minus wage) are simply a constant fraction of output.

The parameter α captures the degree of decreasing returns. If $\alpha = 1$ the model exhibits constant returns to scale. We assume the existence of adjustment costs in the process of capital accumulation. Following Abel (2003), we propose a characterization of adjustment costs that fits easily into a log-linear framework. In particular, the stock of capital next period is given by

$$K_{t+1} = \left(I_t^{\nu} I_{t-1}^{1-\nu}\right)^{\phi} K_t^{1-\phi}. \tag{21}$$

Where $0 \leqslant \nu \leqslant 1$ and $0 \leqslant \phi \leqslant 1$. Our parameterization of adjustment costs implies that there are standard capital adjustment costs (as in Abel 1979, Hayashi 1982), and simultaneously investment adjustment costs (as in Christiano, Eichenbaum, and Evans 2005). This equation also encompasses the loss of capital due to depreciation. If $\phi = 0$, we are in a Lucas' tree model with constant capital stock and no depreciation. If $\phi = 1$ (and $\nu = 1$), we are in the neoclassical model with full depreciation.

To see more clearly how the different adjustment costs enter the model, define Q_t as the price of a unit of installed capital in terms of consumption foregone today (see Abel 2003):

$$Q_t = \left(\frac{dK_{t+1}}{dI_t}\right)^{-1} = \frac{1}{\nu\phi}\left(\frac{I_t}{K_t}\right)^{1-\phi}\left(\frac{I_t}{I_{t-1}}\right)^{\phi(1-\nu)}. \tag{22}$$

Installed capital becomes more expensive as the investment-to-capital ratio increases, which is a standard result in the q-theory. In this model, capital also becomes more expensive when current investment increases relative to past investment.

Investment in this model is proportional to the market value of the capital stock, $Q_t K_{t+1}$, which is equal to

$$Q_t K_{t+1} = \frac{1}{\nu\phi} I_t. \tag{23}$$

In other words, the market value of the capital stock should be a sufficient statistic for investment. This simple model gives the usual prediction that if we account for the price of installed capital relative to its replacement cost, earnings should have no additional predictive value for investment-to-capital ratios.

4.2 Equilibrium Condition

In order to link investment to primitive parameters, we close the model with an equilibrium condition derived from the optimal behavior of a representative equity-holder who holds the capital stock in the economy. The standard equilibrium condition used in consumption-based asset pricing is derived from the consumer's first-order condition, that is, $1 = E_t[M_{t+1}R_{t+1}]$, where M_{t+1} is the stochastic discount factor (SDF) and R_{t+1} is the return on any given asset. This equilibrium condition applied to the capital stock of the economy implies that

$$1 = E_t\left[M_{t+1}\left(\frac{Y_{t+1} - I_{t+1} + Q_{t+1}K_{t+2}}{Q_t K_{t+1}}\right)\right]$$
$$= E_t\left[M_{t+1}\left(\frac{Y_{t+1} - I_{t+1} + \frac{1}{\nu\phi}I_{t+1}}{\frac{1}{\nu\phi}I_t}\right)\right]. \tag{24}$$

Intuitively, the return on capital has a cash-flow piece, which corresponds to consumption ($Y_{t+1} - I_{t+1}$), and a capital gain piece. Since market values are proportional to investment, capital gains can be expressed in terms of investment growth.

4.3 Log-Linear Model

We now make functional assumptions and take approximations in order to match the log-linear framework we developed in the first part of the article. First, we log-linearize the return on capital, which abstracting from constants is equal to[11]

$$r_{t+1} = \log\left(\frac{Y_{t+1} - I_{t+1} + \frac{1}{\nu\phi}I_{t+1}}{\frac{1}{\nu\phi}I_t}\right)$$
$$\approx (1 - \rho_r)(y_{t+1} - i_{t+1}) + \Delta i_{t+1}. \tag{25}$$

Log productivity shocks (z_{t+1}) are assumed to be exogenous and follow a simple AR(1) process:

$$z_{t+1} = \phi_z z_t + \varepsilon_{z,t+1}, \tag{26}$$

where $\varepsilon_{z,t+1}$ is a standard normal shock, with mean zero and standard deviation σ_z. Subtracting z_t from both sides of (26) and taking expectations:

$$E_t[\Delta z_{t+1}] = E_t\left[(\phi_z - 1)z_t + \varepsilon_{z,t+1}\right]$$
$$= (\phi_z - 1)(\phi_z z_{t-1} + \varepsilon_{z,t}). \tag{27}$$

When ϕ_z is between zero and one, a positive productivity shock ($\varepsilon_{z,t}$) today leads to lower expected productivity growth ($E_t[\Delta z_{t+1}]$) for tomorrow.

The log version of the intertemporal equilibrium condition is $1 = E_t[\exp(m_{t+1} + r_{t+1})]$, hence we need to define the log SDF. The functional form that we assume is

$$m_{t+1} = -r_f - \frac{1}{2}x_t^2\sigma_z^2 - x_t\varepsilon_{z,t+1}. \tag{28}$$

11. The log-linearization parameter is $\rho_r = \frac{1-\nu\phi}{(1-\nu\phi)+\nu\phi\exp\{E[y_t - i_t]\}}$.

This specification of the SDF follows Jermann (1998) and Lettau (2003) in the sense that only productivity shocks are priced in this production economy. The shock x_{t+1} works as a taste shifter that captures changes in investor preferences (i.e., risk aversion). We also assume it follows an AR(1) process:

$$x_{t+1} = \phi_x x_t + \varepsilon_{x,t+1}, \tag{29}$$

where $\varepsilon_{x,t+1}$ is a standard normal shock, with mean zero and standard deviation σ_x. The correlation between the two shocks is ρ_{xz}.

4.4 Model Solution

Using the equilibrium condition and the other assumptions, one can show that (log) investment is of the following form:

$$i_t = B + B_z z_t + B_x x_t + B_k k_t + B_i i_{t-1}. \tag{30}$$

We expect to find that investment responds positively to productivity ($B_z > 0$) since investment is procyclical in the data. On the other hand, we expect investment to respond negatively to a higher price of risk ($B_x < 0$). Finally, a higher capital stock and higher past investment imply that adjustment costs are proportionally lower, leading to higher investment ($B_k > 0$ and $B_i > 0$).[12] The equations that define the relevant parameters are given in Appendix C.

We can now express the items in the variance decomposition as functions of the primitive parameters and shocks in this economy. Shocks to earnings, investment, and returns are all driven by shocks to productivity and the price of risk. Unexpected investment can be decomposed as follows:

$$\Delta i_{t+1} - E_t \Delta i_{t+1} = B_z \varepsilon_{z,t+1} + B_x \varepsilon_{x,t+1}, \tag{31}$$

$$C_{r,t+1} = \frac{1}{\theta - 1} \left\{ [(1 - \rho_r) + \rho_r B_z] \varepsilon_{z,t+1} + \rho_r B_x \varepsilon_{x,t+1} \right\}, \tag{32}$$

$$C_{y,t+1} = \frac{\theta}{\theta - 1} \varepsilon_{z,t+1}, \tag{33}$$

$$\begin{aligned} N_{cf,t+1} = & \left\{ \frac{\theta}{\theta - 1} \left[\frac{\rho(\phi_z - 1)}{1 - \rho\phi_z} + \alpha\lambda\kappa_z \right] - (\kappa_z - B_z) \right\} \varepsilon_{z,t+1} \\ & + \left\{ \frac{\theta}{\theta - 1} \alpha\lambda\kappa_x - (\kappa_x - B_x) \right\} \varepsilon_{x,t+1}, \end{aligned} \tag{34}$$

12. We also expect to find $B_k < 1$ since the unit price of capital (q_t) should be decreasing in the stock of capital from the assumption of diminishing returns (Romer 1996).

$$N_{r,t+1} = -\left(B_z\varepsilon_{z,t+1} + B_x\varepsilon_{x,t+1} + C_{r,t+1} - C_{y,t+1} - N_{cf,t+1}\right), \tag{35}$$

where $\lambda = \rho\phi[\nu + \rho(1-\nu)]/[1-\rho(1-\phi)]$, $\kappa_z = \frac{1}{1-\lambda B_k - \rho B_i}\frac{1-\rho}{1-\rho\phi_z}B_z$, and $\kappa_x = \frac{1}{1-\lambda B_k - \rho B_i}\frac{1-\rho}{1-\rho\phi_x}B_x$.[13]

A couple of conclusions can be quickly drawn. First, the shock to current earnings $C_{y,t+1}$ in equation (33) is basically the shock to productivity. On the other hand, unexpected investment growth in equation (31) is a response to both the shock to productivity and the shock to the price of risk. As conjectured by Lamont (2000), earnings shocks and investment shocks can be positively correlated as long as the shock to the price of risk does not offset the effect of productivity shocks.

Second, future cash-flow news are a function of the shock to productivity and the price of risk, and not only of the shock to productivity. This happens because future cash flows depend on the endogenous response of investment to the price of risk.

Third, from (31) and (32) it is easy to see that unexpected returns behave essentially like unexpected investment growth, particularly since $\rho_r \approx 1$ (see also Cochrane 1991). Intuitively, unexpected investment responds to the same shocks that affect market values, therefore they must be highly correlated. It follows immediately that whatever correlation there is between earnings surprises and investment surprises, the model predicts a similar correlation between earnings surprises and return surprises. If surprises to investment and earnings are highly correlated, then it has to be the case that surprises to earnings and returns are highly correlated as well in the model.

4.5 Calibration

We calibrate most parameters by taking standard values in the literature. The share of capital α is set at 0.30 in the baseline case although we also show results for the case of constant returns to scale ($\alpha = 1$). For the adjustment cost function, we set $\phi = 0.10$ and $\nu = 0.50$ as the baseline numbers ($\nu = 1$ implies no investment adjustment costs). We get $\rho_r = 0.93$ using these numbers and an average earnings-investment ratio ($E[Y_t/I_t] \simeq \exp(E[y_t - i_t])$) of 1.377, which is close to the average in our quarterly sample.

Following Lettau and Wachter (2007), we set $\sigma_x = 0.12$ and $\phi_x = 0.95$ in order to match the autocorrelation of the dividend yield. The persistence of productivity is $\phi_z = 0.99$. As is standard in the macroliterature, productivity is close to a random walk (see, e.g., Campbell 1994, Lettau 2003). This implies that productivity shocks are highly persistent instead of transitory noise. In the benchmark case, productivity shocks and shocks to the price of risk are assumed to be perfectly and negatively correlated ($\rho_{xz} = -1$) as in Campbell and Cochrane (1999). We calibrate the volatility

13. We define discount rate news in (35) as the residual from the budget constraint to ensure that the variance decomposition holds. There is an alternative way to define discount rate news directly from the definition of returns. However, the partial equilibrium nature of the model, given that the SDF is defined exogenously, does not enforce the aggregate budget constraint on which our decomposition is based.

of productivity shocks from the volatility of cash flows, which are equivalent in this model. We set $\sigma_z = 0.134$, which is close to the volatility of asset cash-flow growth in our quarterly sample.[14]

Table 10 shows the variance decomposition for various parameter choices of adjustment costs, and the volatility and correlation of shocks. The left-hand side panel shows results for the case with $\alpha = 0.3$. The variance of investment is higher than the one seen in the data, except when ϕ is low (i.e., when capital adjustment costs are severe). For instance, when $\phi = 0.01$ the variance of investment is 0.0069 which is close to the variance seen in the FOF sample. Capital adjustment costs have a larger impact on the level of investment volatility than investment adjustment costs (i.e., variation in ν). Across the different cases with $\alpha = 0.3$, the covariance between shocks to earnings and investment growth is about twice the variance of investment growth, and it corresponds to the largest element in the variance decomposition. Therefore, the model is capable of matching this key feature of the data.

The cases reported with $\alpha = 0.3$ also match the negative covariance between investment surprises and long-run cash-flow news seen in the data, although the magnitudes are smaller than in the data. This contrasts sharply with the case of constant returns to scale ($\alpha = 1$) where the covariance of investment surprises and long-run cash-flow news is positive and, in most cases, the largest element in the variance decomposition.

To better understand the intuition behind these comovements, we examine the impulse responses to a positive productivity shock. Figure 2 plots the future dynamics of the main variables from year 2 to year 500 (the current year or year one is not shown). For constant return to scale ($\alpha = 1$), the positive productivity shock pushes up investment, output, and returns contemporaneously. But beyond the current year, the good shock slowly decays into the future according to equation (27), so both capital and investment keep increasing but at a declining rate. As a result, future investment growth and output growth converge to zero from above. This implies that future cash-flow news is positive. In this case, the covariance between current investment growth and future cash-flow news is positive ($\text{cov}(\Delta i, N_{cf}) > 0$). With decreasing returns to scale ($\alpha = 0.3$), the current impact of the positive productivity shock on investment and output is smaller. The impact on future capital and investment is also less pronounced. In fact, the optimal level of capital peaks very soon and then starts declining. As a result, investment growth and output growth are both negative in the long run and future cash-flow news is negative. In this case, the covariance between current investment growth and future cash-flow news is negative ($\text{cov}(\Delta i, N_{cf}) < 0$).

In the case of $\alpha = 0.3$, the positive covariance between investment growth and returns is the second largest element in the decomposition. This result is almost hard-wired into our model. Unfortunately, it is strongly counterfactual as we saw in the data. The third largest element is the covariance of investment with discount rate news. In most cases in Table 10, discount rate news is strongly and negatively

14. This number is quite high when compared to typical assumptions for the standard deviation of technology shocks in the macro literature (see, e.g., King and Rebelo 1999).

TABLE 10

Variance Decomposition: Model Implied

	$\alpha = 0.3$						$\alpha = 1$					
	ν			ϕ			ν			ϕ		
	0.25	0.75	1	0.01	0.05	0.1	0.25	0.75	1	0.01	0.05	0.1
	level											
var(i)	0.0262	0.0268	0.0258	0.0069	0.0238	0.0279	0.0019	2.5746	0.2763	0.0414	2.4726	9.2238
	as % of investment variance											
cov(i, Cy)	191%	180%	2%	370%	200%	185%	−702%	19%	59%	151%	−20%	−10%
cov(i, Ncf)	−12%	−14%	−16%	−113%	−20%	−11%	1397%	563%	591%	35%	296%	361%
-cov(i, Cr)	−129%	−128%	−127%	−130%	−130%	−128%	−112%	−118%	−117%	−130%	−125%	−121%
-cov(i, Nr)	51%	53%	52%	−27%	50%	55%	−483%	−364%	−433%	43%	−51%	−130%
	correlations											
Corr(i, Cy)	1.00	1.00	1.00	1.00	1.00	1.00	−1.00	1.00	1.00	1.00	−1.00	−1.00
Corr(Cy, Cr)	1.00	1.00	1.00	1.00	1.00	1.00	−1.00	1.00	1.00	1.00	−1.00	−1.00
Corr(i, Cr)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	ρ_{xz}			σ_x/σ_z			ρ_{xz}			σ_x/σ_z		
	−1	0	1	0.5	1	2	−1	0	1	0.5	1	2
	level											
var(i)	0.0279	0.0203	0.0147	0.0237	0.0291	0.0464	9.2238	0.3507	0.0624	0.7038	88.167	0.2321
	as % of investment variance											
cov(i, Cy)	185%	214%	254%	200%	181%	143%	−10%	−40%	−123%	−37%	−3%	64%
cov(i, Ncf)	−11%	−27%	−50%	−20%	−9%	12%	361%	549%	1073%	528%	318%	−105%
-cov(i, Cr)	−128%	−129%	−131%	−129%	−130%	−127%	−121%	−120%	−116%	−120%	−121%	−124%
-cov(i, Nr)	55%	43%	27%	48%	57%	71%	−130%	−289%	−734%	−272%	−94%	265%
	correlations											
Corr(i, Cy)	1.00	0.99	1.00	1.00	1.00	1.00	−1.00	−0.77	−1.00	−1.00	−1.00	1.00
Corr(Cy, Cr)	1.00	0.99	1.00	1.00	1.00	1.00	−1.00	−0.76	−1.00	−1.00	−1.00	1.00
Corr(i, Cr)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Notes: This table shows the variance decomposition results using the simple log-linear q-theory model for various parameter choices. The left-hand side panel assumes decreasing returns to scale, and the right-hand side panel assumes constant returns to scale. We decompose the variance of unexpected investment growth rate into covariances with each of its four components: (i) Cy: current cash-flow surprises, (ii) Ncf: future cash-flow news, (iii) Cr: current return surprises, and (iv) Nr: future discount rate news. The table also shows correlation coefficients between the different terms. All other calibration parameters are described in Section 4.5.

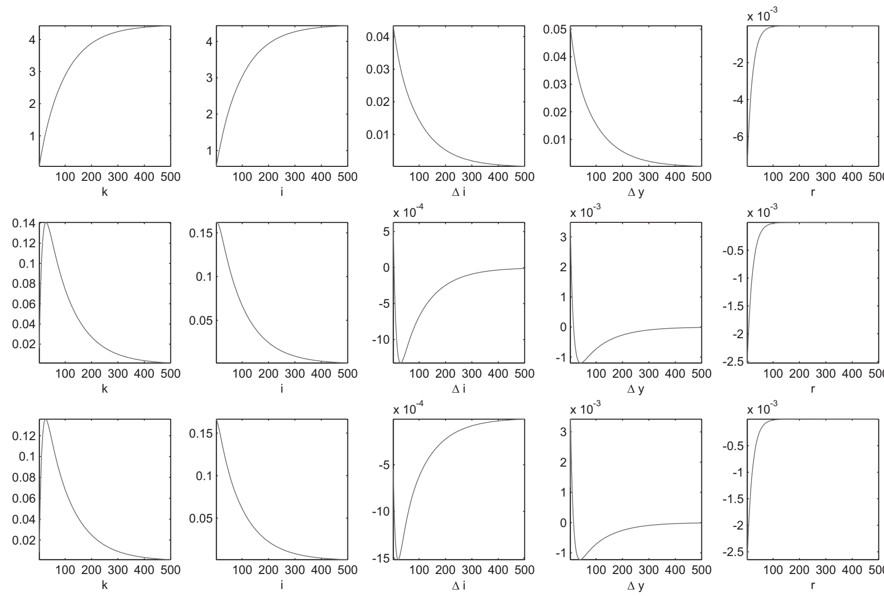

FIG. 2. Future Responses to a Productivity Shock.

NOTE: We introduce a positive productivity shock to our calibrated simple model for investment growth and examine the future responses in capital (k), investment (i), investment growth (Δi), output growth (Δy), and return (r) from year 2 to year 500. The first row corresponds to the case where $\alpha = 1$ and $\nu = 1$; the second row corresponds to the case where $\alpha = 0.3$ and $\nu = 1$; the third row corresponds to the case where $\alpha = 0.3$ and $\nu = 0.5$. All other calibration parameters are described in Section 4.5.

correlated with investment. In other words, positive updates to future discount rates typically lead to lower current investment in the model.

When $\alpha = 1$, the covariance of investment surprises and return surprises is also positive and large. The covariance with discount rate news is mostly positive, which fits the data. However, there are other counterfactual results when $\alpha = 1$. First, the covariance of investment and earnings surprises is much reduced and it even turns negative in some cases. Second, investment is much more volatile in the case of constant returns to scale.

Overall, the model with decreasing returns to scale fits the data better. First, the level of investment volatility is closer to the one observed in the data. Second, the model is able to reproduce the large covariance of investment and earnings surprises. It seems as if the importance of earnings surprises in the case of decreasing returns is substituted for an increased importance of long-run news in the case of constant returns to scale. Finally, when there are constant returns to scale, investment surprises and earnings surprises are often negatively correlated, which is highly counterfactual.

The main challenge to this simple model lies in the behavior of returns in connection to investment growth. In the model, the correlation between investment and return surprises is positive and high irrespective of the degree of returns to scale or other parameter choices. From an asset pricing perspective, and given that investment growth and returns are basically the same in this model, one can imply that return surprises are highly correlated with current cash-flow surprises and that discount rate news are relatively unimportant for returns. This is in contrast with many asset pricing results (for instance, Campbell 1991 and Cochrane 2008, although see Chen and Zhao 2009 for a dissenting view).

The model also illustrates that one can match the cash-flow side of the variance decomposition without matching the return side. However, and precisely for this reason, the model is only a partial answer to what moves investment. Looking at the entire variance decomposition imposes discipline on the precise mechanism one can argue is working behind the dynamics of investment.

5. CONCLUSIONS

Starting from the intertemporal budget constraint of the firm, we show that unexpected investment growth can be decomposed into four elements: unexpected current cash-flow growth, unexpected current returns, revisions to expectations of future cash-flow growth, and revisions to expectations of future discount rates. We find that aggregate investment variation is predominantly related to current cash-flow shocks. The terms related to current and future returns are small and have unintuitive signs. Therefore, the role of the discount rate channel for investment appears to be secondary at best.

APPENDIX

This appendix contains three sections. Appendix A provides additional details by relating our identities to the firm-level flow of fund identity discussed in Gatchev, Pulvino, and Tarhan (2010). Appendix B provides details about the log-linearization of the present-value relation involving cash flow, investment, and discount rates. Appendix C presents additional details on model solution and intuition.

APPENDIX A: FLOW OF FUND IDENTITY: FIRM LEVEL VERSUS AGGREGATE LEVEL

The sources of funds must be equal to uses of funds for each individual firm, which leads to the following two equations (see equations (2) and (3) in Gatchev, Pulvino, and Tarhan (2010)):

$$\begin{aligned} CF_t &= \Delta Cash_t + RP_t + DIV_t + INV_t + ACQUIS_t - \Delta LTD_t \\ &\quad - \Delta STD_t - EQUISS_t - ASALES_t, \\ CF_t &= EBITDA_t - INTEXP_t - TAX_t - \Delta NWC_t, \end{aligned}$$

where *CF* denotes internally available cash flow for investment and financing; $\Delta Cash$ denotes change in cash balance; *RP* denotes shares repurchase; *DIV* denotes dividends; *INV* denotes investment; *ACQUIS* denotes acquisitions; ΔLTD denotes changes in long-term debt; ΔSTD denotes changes in short-term debt; *EQUISS* denotes equity issuance; *ASALES* denotes asset sales; *EBITDA* denotes earnings before interest, taxes, and depreciation; *INTEXP* denotes interest expenses; *TAX* denotes cash taxes; ΔNWC denotes change in net working capital.

Combining the above two equations and aggregating across all firms (public and private) in the economy, we have:

$$\begin{aligned} &EBITDA_t - INTEXP_t - TAX_t - \Delta NWC_t - \Delta Cash_t + EQUISS_t - RP_t \\ &\quad = DIV_t + INV_t - \Delta LTD_t - \Delta STD_t. \end{aligned}$$

Note $ASALES_t$ and $ACQUIS_t$ do not appear since they cancel out each other in aggregate. To map to our aggregate flow of fund identity (equation (2) in the article), we define:

$$\begin{aligned} EARN_t &= EBITDA_t - INTEXP_t - TAX_t, \\ CFADJ_t &= -\Delta NWC_t - \Delta Cash_t, \\ NI_t^E &= EQUISS_t - RP_t, \\ NI_t^D &= \Delta LTD_t + \Delta STD_t, \\ I_t &= INV_t. \end{aligned}$$

Gatchev, Pulvino, and Tarhan (2010) do not talk about inventory changes separately, since they are included in changes in net working capital (ΔNWC). Therefore, the parallel that we draw in this section with respect to our identities corresponds to the case where investment is identified with fixed investment as in our Section 3.2.

APPENDIX B: LOG-LINEAR APPROXIMATION

Assume that $y_t - e_t$ and $i_t - e_t$ are stationary. The parameters used in the log-linearization are:

$$\rho = \frac{1}{1 + \exp\{E[y_t - e_t]\} - \exp\{E[i_t - e_t]\}}, \tag{B1}$$

$$\theta = \frac{\exp\{E[y_t - e_t]\}}{\exp\{E[y_t - e_t]\} - \exp\{E[i_t - e_t]\}}. \tag{B2}$$

A first-order Taylor approximation of the log of both sides of equation (4) in the article around $E[y_t - e_t]$ and $E[i_t - e_t]$ give equation (7) in the article.

Empirically, $E[y_t - e_t] > E[i_t - e_t]$ so that $\rho < 1$ and $\theta > 1$ are the relevant cases. In the literature on present-value relationships it is standard to set $\rho = 0.99$. For our application, we also arrive to $\rho = 0.99$ by substituting the average cash flow-to-equity and investment-to-equity ratios observed in the sample period 1952:01–2014:04 (4.75% and 3.78%, respectively) into equation (B1). In order to obtain a consistent estimate of θ we note that the stationarity of returns, earnings growth, and investment growth imply that earnings, investment, and equity values are cointegrated. The parameter θ is part of the cointegrating vector between these variables. The ratio v_t is basically the cointegrating relationship. We run the DLS regression of Stock and Watson (1993) to estimate θ.

$$e_t = \alpha + \beta y_t + \gamma i_t + \sum_{j=-k}^{k} [\delta_j \Delta y_{t+j} + \lambda_j \Delta i_{t+j}] + \epsilon_t.$$

Our analysis implies that $\beta = \theta$ and $\gamma = -(\theta - 1)$. In the period 1952:01–2014:04, we obtain values of β between 1.68 and 2.35, and γ between -0.76 and -1.52, depending on the particular subsample and the number of lags (k). We set $\theta = 1.77$ for our analysis. Our results are virtually unchanged for similar values of θ.

In order to assess the accuracy of the log-linear approximation, we compare investment growth with its log-linear equivalent, that is, we compare both sides of the following equation that is derived from equation (7) in the article:

$$\Delta i_{t+1} = \underbrace{\frac{1}{\theta - 1}(v_t - r_{t+1} + \theta \Delta y_{t+1} - \rho v_{t+1})}_{\text{approximate investment growth}} \tag{B3}$$

	Exact investment growth (1)	Approximate investment growth (2)	Approximation error (1) − (2)
Std. deviation	0.0683	0.0688	0.0046
Correlation with (1)	1.0000	0.9978	−0.0735

As reported in the above table, the correlation between investment growth and its approximate version is 0.99 in the main quarterly sample. The approximation error has a standard deviation of only 0.0046. The correlation between investment growth and the approximation error is -0.07.

APPENDIX C: ADDITIONAL DETAILS ON THE MODEL

In this section, we first provide detailed solutions to the optimal investment in our simple model in Section 4 of the article.

The coefficients on the investment equation are defined by:

$$0 = \rho_r \phi \nu B_k^2 + \rho_r B_k B_i + [(1-\rho_r)\phi\nu\alpha - 1 + \rho_r(1-\phi)] B_k + (1-\rho_r)(1-\phi)\alpha, \tag{C1}$$

$$0 = \rho_r B_i^2 + \rho_r \phi \nu B_k B_i + [(1-\rho_r)\phi\nu\alpha - 1] B_i + \rho_r \phi (1-\nu) B_k + (1-\rho_r)(1-\nu)\phi\alpha, \tag{C2}$$

$$B_z = \frac{(1-\rho_r)\phi_z}{1-(1-\rho_r)\phi\nu\alpha - \rho_r\phi_z - \rho_r\phi\nu B_k - \rho_r B_i}, \tag{C3}$$

$$B_x = -\frac{[(1-\rho_r)+\rho_r B_z]\sigma_z^2}{1-(1-\rho_r)\phi\nu\alpha - \rho_r\phi_x - \rho_r\phi\nu B_k - \rho_r B_i + \rho_r\sigma_{xz}}. \tag{C4}$$

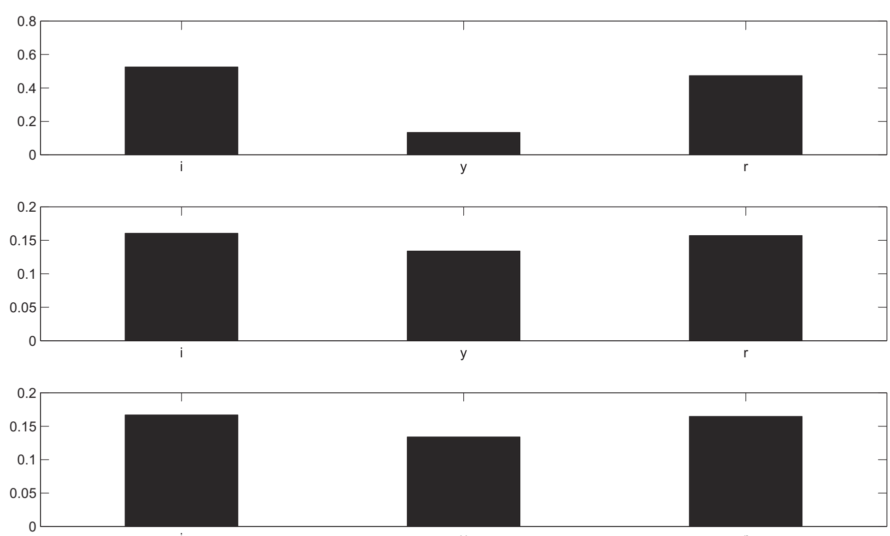

FIG. 3. Contemporaneous Response to a Productivity Shock.

NOTE: We introduce a positive productivity shock to our calibrated simple model for investment growth and examine the optimal response in investment (i), output (y), and return (r) contemporaneously. The first row corresponds to the case where $\alpha = 1$ and $\nu = 1$; the second row corresponds to the case where $\alpha = 0.3$ and $\nu = 1$; the third row corresponds to the case where $\alpha = 0.3$ and $\nu = 0.5$. All other calibration parameters are described in Section 4.5.

Out of the roots for B_k that follow from equations (C1) and (C2), we pick the root that lies between zero and one.

Figure 3 plots the contemporaneous response of investment (i), output (y), and returns (r) to a positive productivity shock in our model. For constant return to scale ($\alpha = 1$), the positive productivity shock pushes up investment, output, and returns contemporaneously (see the first row in Figure 3). With decreasing returns to scale ($\alpha = 0.3$), the impact of the positive productivity shock on current investment and output is smaller (see second row in Figure 3).

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