Revisions of Investment Plans and the Stock Market Rate of Return

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Abstract

This paper explores the sources of uncertainty that cause firms to revise their capital investment plans and the stock market to revise its valuation of those firms. A simple method is developed to decompose the uncertainty governing revisions in investment plans and the stock market rate of return into micro, sectoral and aggregate components, and to measure the degree of heterogeneity in micro responses to common disturbances. The method is applied to a panel data set of fims in the U.S. economy for the period 1950-1973. The empirical results show that the capital investment decision is governed primarily by idiosyncratic uncertainty, but common disturbances are more important for movements in the stock market rate of return.

Keywords: capital investment plans; revisions; uncertainty; common disturbances; stock market rate of return.

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This paper explores the sources of uncertainty that cause firms to revise their capital investment plans and the stock market to revise its valuation of those firms. The central question addressed in the paper is whether capital investment is determined primarily by factors that are idiosyncratic to the firm or factors that are common across firms. A simple method is developed to decompose the uncertainty governing revisions in investment plans and the stock market rate of return into micro, sectoral and aggregate components, and to measure the degree of heterogeneity in micro responses to common disturbances. The method is applied to a panel data set of firms in the U.S. economy for the period 1950–1973.

The source of uncertainty faced by agents (i.e., the relative variance of micro and aggregate disturbances) has significant implications both for theoretical modelling and microeconometric practice. At the most general level, the structure of uncertainty should influence the development of both single agent and market equilibrium dynamic stochastic models. Empirical evidence of large micro variance would indicate the need to develop dynamic structural equilibrium models with heterogeneous agents rather than models with representative agents and aggregate disturbances. The specification, estimation, and methods to compute equilibrium for such models all depend on the type of uncertainty faced by agents (see Pakes, 1991, for excellent discussion). Recent dynamic structural models with heterogeneous agents incorporate idiosyncratic uncertainty but do not allow for aggregate disturbances (Ericson and Pakes, 1990; Hoppenhayn and Rogerson, 1990). Whether that is an important limitation remains an empirical question.

In the business cycle literature, different classes of models can be identified in part by their specification of uncertainty. Monetary models based on misperception by agents between micro and macro disturbances were originally justified by Lucas on the empirical claim that micro disturbances are the main source of uncertainty, so that agents have no incentive to design information processing mechanisms to diagnose aggregate disturbances correctly. Referring to investment decisions specifically, he says "one must insist on the minor contribution of economy-wide risk to the general risk situation faced by agents" (Lucas, 1977, p. 23). At the other extreme are real business cycle models based on representative agents facing aggregate uncertainty (Kydland and Prescott, 1982). Recent work has shown that the cross sectional covariation generated by aggregate shock models can also arise from models in which idiosyncratic disturbances are transmitted across agents by some mechanism, such as input-output linkages, strategic interactions, and inventory behaviour (Long and Plosser, 1983; Jovanovic, 1987; Cooper and Haltiwanger, 1991). Hence the choice of modelling strategy in this field, as in others, should depend in part on whether the underlying economic and technological uncertainty is idiosyncratic or common, and this cannot be determined simply by observing the path of endogenous variables. Empirical evidence on the sources of uncertainty would help direct theoretical modelling.

Another example are the theoretical models designed to reconcile discontinuous behavior at the microeconomic level, arising from kinked or nonconvex adjustment costs, with "smooth" movements at the aggregate level (for extensive discussion, see Bertola and Caballero, 1990). The key feature of these models is imperfect syncronisation across agents generated by idiosyncratic uncertainty. The degree of aggregate smoothness produced by these models depends directly on the relative variance of micro and common disturbances.

Recent papers exploit economic theory to impose an a priori structure on the cross sectional dependence among agents. In analyses of micro consumption behaviour, the assumption that agents have access to complete (insurance) markets in income streams has been used to ensure that all idiosyncratic risk is diversified in equilibrium, leaving only aggregate disturbances in the Euler equation (Altonji, Hayashi and Kotlikoff, 1990; Altug and Miller, 1990). This approach has not been applied to investment behaviour, but the strong implication for Euler equation disturbances is testable. An empirical finding that idiosyncratic disturbances are present in investment decisions would indicate that imperfections in the capital markets do not allow for complete diversification against micro risk, and suggest how important those imperfections are.

On the econometric side, the structure of uncertainty is a critical determinant of the appropriate estimation procedure for single agent dynamic optimisation models. The consistency (in the cross sectional dimension) of standard method of moments estimators for Euler equations is based on the assumption that disturbances average out across agents. This consistency property requires that disturbances are idiosyncratic and does not hold if there are common shocks. Pakes (1991) shows that the standard procedure of removing aggregate components by time-specific dummy variables is only valid under the condition that the control variable in period t+1 is not affected by the factor inducing dependence in the state variable across agents in period t. This condition is unreasonable in most economic contexts, including capital investment, unless the stochastic process generating the common factor is serially independent. Consistency may be preserved if there is sufficient heterogeneity in the responses of different micro agents to the aggregate disturbance, so that cross sectional dependence is reduced (Pakes, 1991). Nonetheless, there is reason to suspect any empirical results derived from Euler equation estimators in applications where there are common factors inducing dependence across agents and their variance is not "sufficiently small." This paper provides evidence on the variances of micro and common disturbances, and the extent of heterogeneity in micro responses, that can be used to assess the empirical importance of these issues for the capital investment decision.

The empirical research on this topic is very limited, but aggregate disturbances do not appear to be the major source of uncertainty. Long and Plosser (1987) use factor analysis to study high frequency fluctuations in sectoral output. They confirm the presence of an aggregate factor but show that the bulk of the variance in sectoral output is accounted for by sectoral shocks (median estimate is 74 percent). Davis and Haltiwanger (1990) document pervasive heterogeneity in the labour market. Using extensive annual data at the establishment level, they show that at least 80 percent of gross job reallocation is idiosyncratic to the establishment. Sectoral and macro disturbances, together with heterogeneous responses to these shocks, account for at most 12 percent of the overall micro variance (see also Lilien, 1982; Abraham and Katz, 1986). To my knowledge, there are no studies of the sources of uncertainty for consumption or capital investment decisions.

This paper uses data on investment plans to study the structure of uncertainty driving capital investment. The approach exploits a basic property of dynamic stochastic investment models under rational expectations, that the revisions of investment plans for a given target date are governed exclusively by unanticipated disturbances ("news") to the information set used by firms to formulate the plans. This property implies that one can analyse the sources of uncertainty directly by studying the sources of variance in the revisions of investment plans. In econometric terms, investment revisions are an indicator of the underlying news in the information set determining investment. The stock market rate of return (referred to as q) is incorporated as a complementary indicator, on the assumption that the investment program maximises the value of the firm.

Using investment revisions to study the sources of uncertainty has two major advantages. First, the approach does not require structural specification of the economic and technological determinants of investment. This means that the empirical findings reported in the paper are robust to alternative specifications of the investment process. Second, the method enables one to measure the contribution of micro shocks before they are transmitted to other firms, and thereby to avoid confusing them with sectoral or aggregate disturbances.

Analysis of variance is used to decompose the investment revisions and q into aggregate, sectoral, and idiosyncratic components. In order to allow for measurement error ("noise") in the survey investment plans and q, a decomposition based on the covariance between investment revisions and q is conducted. This covariance captures only the economically relevant news that determines both investment decisions and q, eliminating the measurement error that affects only one of the variables. The model is then extended to incorporate hetergeneous micro responses to common (sectoral and aggregate) disturbances. A method is developed to estimate the degree of heterogeneity, and hence to distinguish between genuine micro shocks and heterogenous responses to common disturbances. Finally, the paper examines reduced form associations between investment revisions, and q, and three leading determinants of capital investment discussed in the literature - sales, factor prices and cash flow.

The empirical analysis is conducted on an unbalanced panel set for 318 firms operating in U.S. manufacturing and nonmanufacturing sectors during the period 1950-1973. The data are constructed from annual surveys of actual investment and investment plans for multiple (one to four year) horizons, originally gathered by the McGraw-Hill Publishing Company. This data set is matched to stock market and other financial information, taken from Standard and Poor's Compustat and the Center for Research on Stock Prices.

Section 1 summarises the model used to decompose investment revisions and the stock market rate of return into micro, sectoral and macro components. The data set is described in Section 2. Section 3a presents the empirical decomposition of the variance in investment revisions and q, and the covariance between them. Section 3b analyses the extent of heterogeneity in micro responses to sectoral and macro shocks. Section 4 examines the empirical relationship between investment revisions, and q, and (estimates of) the news in sales, factor prices and internal cash flow at the firm level. Concluding remarks summarise the main findings.

1. Statement of the Model

Consider a firm with an infinite horizon that produces output using a single capital good and a set of variable inputs. Assume that all inputs are chosen so as to maximise the expected discounted value of net cash flow. The expectation is taken conditional on the information set available to the firm in period t, denoted by Ω_t. The firm's information set contains all economic and technological information that is relevant in forecasting the distribution of its future cash flows (determinants of demand, factor prices, technological opportunities etc). In principle this may include publicly available elements from the information sets of other firms, so that strategic and other types of interactions among firms are not ruled out in this framework. The sequence of information sets is assumed to be increasing over time ($\Omega_{t-1} \subset \Omega_t$).

Variable inputs can be adjusted costlessly at the beginning of each period. Hence the expenditures on these inputs are set to maximise current profits, given the information set and the expenditures on investment for that period. Let $\pi(I_t,\Omega_t)$ denote current cash flow, defined as operating profits minus the costs associated with gross investment. An investment program in period t consists of a sequence of random variables representing current and future investment expenditures, $\{I_{t+k}\}_{k=0}^{\infty}$. The optimal investment program maximises the expected discounted value of net cash flows. This program is generated by a value function $V(\Omega_t)$ that satisfies the optimality equation

$$V(\Omega_t) = \max_{I_t} \pi(I_t,\Omega_t) + \delta E[V(\Omega_{t+1})|\Omega_t] \tag{1}$$

where δ is the discount factor.[1] The optimal program, $\{I^*_{t+k}\}_{k=0}^{\infty}$, is represented by the following policy function that relates investment expenditures in each period to the information set available to the firm at that time:

$$I^*_{t+k} = F(\Omega_{t+k}) \tag{2}$$

Let $\tilde{I}_{t,k}$ denote the investment planned in period t for period t+k (the k-span investment plan). Because Ω_{t+k} is not known in period t, the policy function in (2) induces a probability distribution on $\tilde{I}_{t,k}$. In the data set used in this paper, however, firms report specific levels of planned investment. I assume that the k-span investment plan formulated by the firm, $I_{t,k}$, corresponds to the conditional expectation of its (random) optimal investment, given the current information set:

$$I_{t,k} = E(\tilde{I}_{t+k}|\Omega_t). \tag{3}$$

Define the k-span investment revision as the percentage difference between the current investment plan for k periods ahead and last period's investment plan for k+1 periods ahead:

$$yk_t = (I_{t,k}/I_{t-1,k+1}) - 1 \tag{4}$$

This revision represents the updating of planned investment expeditures for a given target date. Equations (3) and (4) imply

$$E(yk_t|\Omega_{t-1}) = 0. \tag{5}$$

Equation (5) is the key result: each k–span investment revision is orthogonal to past information and hence serves as an indicator of the news in the information set that governs the investment decision.[2] This orthogonality property follows directly from the rational expectations assumption that the firm fully utilises available information in making its investment decision. Equation (5) does not require any assumptions about which economic variables govern investment or the form of the investment function. It holds for all standard dynamic models of investment, regardless of how much persistence the level of actual or planned investment exhibits, and remains valid if the firm is liquidity constrained in setting its investment program.[3]

The assumption that the investment program maximises the value of the firm, stipulated in equation (1), is not required for the orthogonality property. Under that assumption, however, the value of the firm provides another device to summarise information that is relevant to the determination of optimal investment. This perspective originates with Grunfeld's (1960) empirical use of the stock market valuation of firms to explain capital investment, and was given theoretical justification by Lucas and Prescott (1971). The value of the firm reflects the entire information set available to the firm. In order to focus on the news in the information set, Pakes (1985) reformulates this idea in terms of the one-period excess rate of return on the firm's equity, denoted by q.[4] Pakes' q is computed as capital gains plus dividends per dollar of equity minus the interest rate. Under an arbitrage condition that ensures that no excess returns can be made on the basis of a linear trading rule and publicly available information, q should equal the percentage change in the expected discounted value of the firm's net cash flows caused by the new information accumulated between periods t-1 and t:

$$q_t = \frac{V(\Omega_t) - E[V(\Omega_t)|\Omega_{t-1}]}{E[V(\Omega_t)|\Omega_{t-1}]} \tag{6}$$

Equations (5) and (6) ensure that both investment revisions and q serve as direct indicators of the news in the information set. Hence, the most direct way to reveal the structure of impulses driving investment decisions and the value of the firm is to decompose the variance in these indicators into micro, sectoral, and macro components. One significant advantage of this approach is that data on investment revisions allow one to measure the importance of micro shocks <u>before</u> they are transmitted to other firms, under the reasonable assumption that micro shocks themselves are private information. Micro shocks can be transmitted across agents in various ways, including market transactions in intermediate and capital goods and strategic interactions among firms (Long and Plosser, 1983; Jovanovic, 1987). It is important to measure micro shocks before they are transmitted, since otherwise the common movements induced by transmission will be confounded with genuine macro disturbances and the effect of the latter will be exaggerated (Jovanovic, 1988).

In order to analyse investment revisions and q, let the news in Ω_t be comprised of three nested parts: a macro shock common to all firms, a sectoral shock, and a micro shock that is idiosyncratic to the firm. Denote these shocks by the triple $(\epsilon_t, e_{jt}, u_{ijt})$, where i, j and t represent the firm, sector and year, respectively. These shocks are mutually uncorrelated white noise processes by construction, and are assumed to possess finite second moments.[5] The effect of each of these shocks on investment revisions and q may differ. Let $(\delta_0, \delta_1, \delta_2)$ denote the response parameters of investment revisions to the macro, sector and micro shocks, respectively. These parameters may vary across spans of investment revisions, but they are assumed here to be the same for all firms. Section 3b explores heterogeneity in response parameters. Without loss of generality the shocks are normalised so that the response parameters for q are unity.

The theory implies that both investment revisions and q should be governed by the same news in Ω_t. However, the stochastic specification also allows for factors at each level of aggregation that affect investment revisions or q, but not both. Since reported investment plans are based on survey data, it is natural to interpret variations in investment revisions that are not reflected in q as measurement error. On the other hand, Lach and Schankerman (1989) have documented the empirical importance of unobservable factors that affect q but not investment decisions. Let $(\epsilon_t', e_{jt}', u_{ijt}')$ denote the idiosyncratic factors in q at the macro, sectoral, and micro levels respectively, and $(\epsilon_t'', e_{jt}'', u_{ijt}'')$ be the corresponding factors in investment revisions. These factors are assumed to be mutually uncorrelated, independently and identically distributed random variables, and are uncorrelated with the news in Ω_t by construction.

The specification allows for the investment plan reported by firms to differ from the "true" planned expenditure described by equation (3). Reported plans may reflect only those capital expenditures that have been budgeted by the survey date. The extent of budgeting will depend on the investment span, since presumably the budgeting process becomes more complete as the target date approaches. To allow for this possibility, let the reported k-span investment plan for firm i in year t be $I^{o}_{it,k}=I_{it,k}\exp(\phi_{ik})$, where $I_{it,k}$ is the (unobserved) investment plan under complete budgeting and the parameter ϕ_{ik} measures the degree of incomplete budgeting for the firm. Using a log approximation, the measured k-span investment revision can be written as $yk^{o}_{it}= yk_{it}+[\phi_{ik}-\phi_{i,k+1}]$. The bracketted term is the bias in investment revisions due to incomplete budgeting, which varies with the investment span. In the empirical work I assume that this bias is common to all firms.[6] Note that the mean of investment revisions (over time) for different spans allow one to estimate the average values of ϕ_k.

As described more fully in Section 2, the information structure of the investment surveys implies that investment revisions in period t should reflect news in periods t-1 and t (with weights denoted by θ and $1-\theta$). Using the preceding assumptions, the empirical model can be summarised as

$$q_{ijt} = \mu + \alpha_t + \beta_{jt} + \gamma_{ijt} \tag{7}$$

$$yk_{ijt} = m + \theta(a_t+b_{jt}+g_{ijt}) + (1-\theta)(a_{t-1}+b_{j,t-1}+g_{ij,t-1}) \tag{8}$$

where the error components are related to the underlying shocks as follows: $\alpha_t=\epsilon_t+\epsilon'_t$, $\beta_{jt}=e_{jt}+e'_{jt}$, $\gamma_{ijt}=u_{ijt}+u'_{ijt}$, $a_t=\delta_o\epsilon_t+\epsilon''_t$, $b_{jt}=\delta_1 e_{jt}+e''_{jt}$ and $g_{ijt}=\delta_2 u_{ijt}+u''_{ijt}$ and m and μ are fixed parameters. The parameter m reflects the budgeting bias in investment revisions, and μ allows for an equity risk premium in q. The stochastic specification implies that the error components in both equations (7) and (8) are distributed independently and identically (in the dimensions specified by their subscripts), and are mutually independent except for the covariance components $E(a,\alpha)=\sigma_{a\alpha}$, $E(b,\beta)=\sigma_{b\beta}$, and $E(g,\gamma)=\sigma_{g\gamma}$.

The model takes the form of a nested variance components design (Searle 1971). The econometric problem is to estimate the variance and covariance components in equations (7) and (8). Standard procedures designed for balanced data must be modified to accomodate the unbalanced panel used here. Unbiased estimates are obtained by equating the theoretical second moments implied by the model with those from the sample. Details of the procedure are provided in Appendix 1.

Three points should be kept in mind when interpreting the empirical results. First, the variance components are estimated separately for each investment revision and q. This allows each shock to affect different spans of investment revisions and q in different ways. For example, a transitory micro shock that affects current investment but not investment planned for future periods implies that the relative size of σ_g^2 in equation (7) should differ across investment spans. In theory some shocks (say to oil prices) could move optimal investment and q in opposite directions, so that $\sigma_{a\alpha}$, $\sigma_{b\beta}$, and $\sigma_{g\gamma}$ are negative, but empirically they turn out to be positive. Second, each component contains both news in Ω that is common to investment revisions and q, and "noise" that affects only one of these variables. Third, the serial independence of error components reflects the theory underlying investment revisions and does not require that investment plans themselves are uncorrelated over time.[7]

2. Description of Data: Do Revisions Reflect News?

The analysis is based on annual surveys conducted by the McGraw Hill Company during the period 1949-1973 (see Eisner 1978 for details). The original panel contains data for about 700 firms on current investment and investment plans over a four year horizon.[8] From this universe a subset is extracted by requiring that there be at least one observation on the zero-span revision and that the firm be identified by name. The name of the firm is used to match the investment data to financial information from the Center for Research on Stock Prices (CRSP) to construct q, and to Standard and Poor's Compustat data for other economic variables used in Section 4. These requirements restrict the sample to 318 firms, of which 229 are in manufacturing and 89 in nonmanufacturing industries. Appendix 2 provides the sectoral composition of the sample. The firms in the sample account for 21 percent of sales and 24 percent of capital investment in the United States in 1967.[9] The average firm is quite large but there is substantial cross sectional variation. The median (mean) level of investment and sales are $42 million (113) and $697 million (1723) in 1976 dollars.

Actual investment expenditures and one year ahead plans are available for 1949–1973, but longer span investment plans only for 1958–1973. Firms do not report plans for all investment spans or years, so the data set is unbalanced. I assume that sample selection is nonsystematic, unrelated to the realisations of the shocks in the model. The surveys are distributed in March, so investment revisions constructed from these plans for year t should reflect news that accumulates (roughly) between March in years t–1 and t. The stock market rate of return, however, is computed on a calendar year basis. This difference is periods for investment revisions and q is embodied in the information structure in equations (7) and (8).

Panel A in Table 1 presents summary statistics for investment revisions and q. There are about 140 firms in the sample per year, and between six and eleven annual observations on investment revisions per firm (depending on the investment span). The mean revisions over the entire sample show that firms tend slightly to overestimate investment expenditures one year ahead, but underestimate them over longer horizons. Firms revise longer span investment plans upward as the target date approaches. The distributions of investment revisions and q are skewed to the right. Panel B shows that there is significant positive correlation across different spans of investment revisions. This is consistent with the interpretation of revisions as reflecting the same news in Ω_t, but it may also reflect correlated measurement (reporting) error across investment spans.

The theory implies that the mean investment revision over time should be zero (cross sectional means for a given year reflect common shocks and need not be zero). As described in Section 1, however, reported investment plans may contain a "budgeting bias" which is reflected in the mean investment revision. The overall mean revisions reported in Panel A do indicate the presence of incomplete budgeting in investment plans, and they imply plausible estimates of its magnitude.[10] It should be emphasised that this finding is consistent with the basic interpretation of investment revisions as news in the information set.

Furthermore, the pattern of correlations between investment revisions and q strongly supports the interpretation of revisions as news in the information set. Under the maintained hypothesis that the stock market is efficient, q_t reflects the news accruing during the calendar year. The investment surveys, however, are distributed to firms in March each year and completed sometime later. Letting θ denote the fraction of the calendar year that elapses before completion of the survey, the theory in Section 1 implies that the investment revision in year t should reflect a fraction θ of the news accruing during calendar year t and $(1-\theta)$ of the news from calendar year t-1. Hence each k-span revision in year t should be correlated with q_t and q_{t-1}, but not with leads or higher order lags of q. The covariances of the investment revision with q_t and q_{t-1} provide a consistent estimate of θ. Using equation (7) and (8), $\theta=A/(1+A)$ where $A=cov(yk_t,q_t)/cov(yk_t,q_{t-1})$. This provides a check on the consistency of our interpretation of revisions with the information structure of the data.

Panel B in Table 1 presents the evidence. Each k-span investment revision is significantly correlated with q_t and q_{t-1}, but (with few exceptions) uncorrelated either with leads or higher order lags of q. The implied estimates of θ are similar across investment spans and are entirely consistent with the timing of the surveys. They imply that completed surveys reflect information available through June each year. I conclude from this evidence that investment revisions do reflect news in the information set, and turn next to the variance decomposition of the revisions and q.

3. Empirical Results

3a. Basic Decompositions

Panel A in Table 2 presents the decomposition of the variance in investment revisions and q. More than ninety percent of the variance in investment revisions is due to factors that are idiosyncratic to the firm. The remaining variance is divided about equally between the sectoral and macro dimensions. The null hypothesis that macro effects do not exist is rejected by the data (test statistic T1). However, one cannot reject the hypothesis that there are no sector effects in investment revisions (test statistic T2). The variance decomposition is very similar across the four investment spans. However, the structure of shocks that govern the stock market rate of return is very different. Factors that are common across firms are much more important determinants of q. Fifty percent of the variance in q is due to common (sector and macro) factors, and more than a third of the variance is due to purely macro shocks that common to all firms in the sample. Both the sector and macro effects in q are statistically significant.[11]

The predominance of micro shocks may be due to the presence of large, firm-specific measurement error in investment revisions and q rather than to genuine micro sources of news in Ω_t. As noted earlier, both elements are captured by the variance components in the model. There are two ways to distinguish between measurement error and news. One is to express the model in equations (7) and (8) in terms of the fundamental unobservables -news in Ω_t and measurement error - and estimate it as a multiple indicators factor model. Unfortunately, such a model is underidentified without additional strong assumptions on the stochastic structure of the measurement error.[12] The alternative approach adopted here is to purge the measurement error by focusing on the covariance between investment revisions and q. This covariance captures only the underlying news in the information set, on the assumption that the measurement errors in investment revisions and q are uncorrelated with each other.[13] This assumption is equivalent to saying that revisions in investment plans that are registered in the stock market valuation of the firm are economically relevant and hence not measurement error. The empirical question posed here is, what fraction of the covariance between investment revisions and q at the firm level is common across firms?

Panel B in Table 2 summarises the results. The central finding is that micro shocks account for the bulk of the covariance between investment revisions and q, between 54 and 73 percent. Their importance is smaller than in the variance decomposition of investment revisions, as one would expect if measurement error is present. Sectoral and macro effects also contribute to the covariance between investment revisions and q, and both are statistically significant (test statistics T1 and T2). These results show that, once measurement error is removed, investment revisions are governed by factors at all three levels of aggregation, but micro shocks remain the primary determinant.

3b. Micro Shocks or Heterogeneity?

The large micro component in the variance and covariance decompositions could reflect heterogeneous micro responses to aggregate (or sectoral) disturbances. If this response parameter varies randomly across firms, then the <u>effect</u> of an aggregate disturbance on investment revisions and q will differ across firms and show up as micro (idiosyncratic) variance. However, it is possible to distinguish between heterogeneity and micro shocks by noting that if micro responses to a macro shock are heterogeneous, then the measured variance across firms will increase with the size of the macro shock. Under the maintained hypothesis that the underlying disturbances are covariance stationary, the observed nonstationarity in the measured effects can be used to infer the importance of heterogeneity in response parameters.

For simplicity in this analysis, I express the model in terms of a single non-nested common disturbance (subsuming sector and macro shocks). Suppressing means for notational ease,

$$q_{ijt} = \alpha_i^* \epsilon_{jt} + u_{ijt} \tag{9}$$

$$yk_{ijt} = \theta\beta_i^* \epsilon_{jt} + (1-\theta)\beta_i^* \epsilon_{j,t-1} + v_{ijt} \tag{10}$$

where α_i^* and β_i^* denote firm i's response parameter to the common shock, and ϵ, u and v are mutually independent, identically distributed normal variables with zero mean. Define $\alpha_i^* = \bar{\alpha}+\alpha_i$ and $\beta_i^* = \bar{\beta}+\beta_i$, and let $z=[\alpha_i,\beta_i]$. Each firm draws its response parameters from a common normal distribution, so that $z\sim N(0,\Sigma)$ where Σ need not be diagonal.[14] This model implies the following cross sectional (within-industry) variances for investment revisions and q and the covariance between them, conditional on the industry and year:

$$V(q|j,t) = \sigma_u^2 + \sigma_\alpha^2 \, \epsilon_{jt}^2 \tag{11}$$

$$V(yk|j,t) = \sigma_v^2 + \sigma_\beta^2 [\theta \, \epsilon_{jt} + (1-\theta) \, \epsilon_{j,t-1}]^2 \tag{12}$$

$$C(q,yk|j,t) = \sigma_{uv} + \sigma_{\alpha\beta} \, [\theta \, \epsilon_{jt}^2 + (1-\theta) \epsilon_{jt} \, \epsilon_{j,t-1}] \tag{13}$$

These moments depend on the unobserved common shock, ϵ. However, equations (9) and (10) imply that plim $q_{.jt} = \bar{\alpha}\epsilon_{jt}$ and plim $y_{.jt} = \bar{\beta}[\theta\epsilon_{jt} + (1-\theta)\epsilon_{j,t-1}]$. Using these results, one can derive the following estimable equations for the cross sectional moments

$$V(q|j,t) = \sigma_u^2 + (\sigma_\alpha/\overline{\alpha})^2 \, q_{.jt}^2 \tag{14}$$

$$V(yk|j,t) = \sigma_v^2 + (\sigma_\beta/\overline{\beta})^2 \, yk_{.jt}^2 \tag{15}$$

$$C(q,yk|j,t) = \sigma_{uv} + (\sigma_{\alpha\beta}/\overline{\alpha}\overline{\beta}) \, q_{.jt} \, yk_{.jt} \tag{16}$$

The intercepts in these equations identify the genuine variance (or covariance with q) in micro shocks. The slope parameter identifies the coefficient of variation in micro responses, a measure of the degree of heterogeneity. This coefficient can be used to measure the fraction of the total variance in investment revisions and q (or covariance between them) that is due to heterogeneity in response parameters, and hence to isolate the variation due to genuine micro disturbances.[15]

Table 3 summarises the unweighted least squares parameter estimates for equations (14) and (15). The estimates of $\sigma_\beta/\bar{\beta}$ are quite precise and similar across investment spans. They indicate that there is substantial heterogeneity in the micro responses of investment to common shocks. The response of q to common shocks is less dispersed across firms. This may reflect the fact that some heterogeneity in investment responses arises from variations in accounting conventions that do not affect the stock market valuation of the firm's real assets. The last two rows in the table show the effect of heterogeneity on the decomposition of the variance in investment revisions and q. The fraction of the variance in revisions that is due to heterogeneous micro responses is small, simply because common shocks are not the main determinant of investment decisions. The conclusion remains that micro shocks drive most of the variance in investment revisions. The variance decomposition for q is very different, however. Once the effects of heterogeneity are removed, only 28 percent of the variance in q is accounted for by micro shocks.

The effects of heterogeneity on the covariance between investment revisions and q are summarised in Table 4. The table presents unweighted least squares parameter estimates for equation (16). The positive estimates for $\sigma_\beta/\bar{\beta}$ indicate that firms whose investment decisions are more responsive to common shocks are also characterised by stock market movements that are more sensitive to these disturbances. The implied correlation coefficient between the response parameters in investment revisions and q (denoted by ρ in the table) increases with the investment span, to as much as 0.52 for the three-span revision. Micro responses of near term investment plans to common shocks are not as strongly reflected in the stock market, suggesting that those idiosyncratic responses reflect accounting and other "extraneous" characteristics of the firm unrelated to the underlying profitability of the investment decisions. Nonetheless, the last two rows in the table show that this correlated heterogeneity does not alter the covariance decomposition substantially for any of the investment spans. Even after removing the effects of heterogeneity, micro shocks still account for between 53 and 67 percent of the covariance between revisions and q.[16]

4. Determinants of Investment Revisions and q

The decompositions of the variance and covariance in investment revisions and q in Section 3 do not depend on which variables appear in the information set. This section extends the analysis by exploring the empirical determinants of investment revisions and q at the firm level. This analysis allows us to reconfirm the interpretation of revisions as news in the information set by checking that they are correlated with determinants of capital investment documented in the literature. I focus on three economic variables that figure prominently in the literature on capital investment – factor prices, demand and cash flow.

According to the theory, investment revisions and q should reflect news in the information set. Since the news cannot be directly observed, I estimate a second order vector autoregression in factor prices, demand and cash flow and use the residuals as estimates of the news. The procedure is to regress investment revisions and q on the (estimated) news in the three economic variables. These regressions do not have a structural interpretation and should be thought of as reduced form associations.

In order to conduct the analysis, it was necessary to match Compustat data to the investment survey data. The merged data set contains about ninety percent of the original firms for the abbreviated period 1954-1973. Two variables are used to capture demand and input prices – undeflated sales and a measure of average variable cost ("factor prices" hereafter).[17] Cash flow for the firm is measured as pre-tax, net operating income before depreciation. These variables, taken from Compustat, are firm-specific and common shocks are removed by fixed year effects.

Table 5 summarises the empirical results. The parameters correspond to elasticities of investment (plans) with respect to news in the associated variables. The information structure in these regressions is not clearcut. The data on sales, cost and cash flow correspond to the firm's fiscal year, but the fiscal year itself is not reported by Compustat and generally differs from the calendar year (for q) and the collection date for the investment surveys. Hence the unrestricted regressions (not reported) include current and two lagged values of the news in each explanatory variable. Test statistics T1 and T2 show that investment revisions respond only to current news, while q also responds to news lagged one period. The table reports the parameter estimates for this restricted version.

Investment revisions are negatively related to news in factor prices and directly related to news in sales. The estimated elasticity of investment (plans) with respect to the news in sales is somewhat lower than the unit value implied by an accelerator model of investment with constant returns to scale. The coefficient on news in sales is similar across investment spans, indicating that the effect of sales on investment plans is not transitory. These findings are consistent with the large empirical literature on capital investment. The stock market rate of return is negatively correlated with news in factor prices but, surprisingly, only weakly and inversely related to news in sales. The news in cash flow has a significant positive effect on q and on all (but the zero-span) investment revisions. The effect on q is not surprising since the stock market is valuing the expected stream of cash flows and hence should react to any news in current cash flow. The empirical link between cash flow and investment revisions is consistent with many other studies. Earlier studies focus on the relationship between the level of capital expenditures and the level of cash flow, conditioning on investment demand variables such as sales and Tobin's Q. The focus here on investment revisions and the news in cash flow is novel, yet the estimated elasticity of investment (plans) with respect to news in cash flow is broadly similar to estimates from recent microeconometric studies (Eisner, 1978; Hayashi and Inoue, 1990; Bond and Meghir, 1990; and Fazzari, Hubbard and Petersen, 1988). The lack of correlation between news in cash flow and the zero-span revision probably reflects precommitment to capital expenditures over such a short horizon.

The r-squares in these equations are low, but they are not an informative index of fit because of the measurement error in reported investment plans and q. A more meaningful measure is the fraction of the <u>covariance</u> between investment revisions and q accounted for by the regression, denoted by f in the table. On this measure, the news in sales, factor prices, and cash flow are important determinants of investment plans. They account for between 34 and 46 percent of the covariance between investment revisions and q at the firm level.

The observed correlation between news in cash flow and investment revisions does not necessarily imply that firms are liquidity constrained. Variations in cash flow convey information both about the liquidity position of the firm and the profitability of investment opportunities. The regressions control for news in sales and factor prices, but these may not fully capture fluctuations in investment demand. In order to investigate the liquidity hypothesis I follow the procedure suggested by Fazzari, Hubbard and Petersen (1988). They segregate firms <u>a priori</u> according to whether they are likely to be cash constrained, and then test the liquidity constraint hypothesis by looking for differential responses of investment to cash flow across these groups. Recent theoretical literature on a hierarchy of sources of finance (Meyers and Majluff, 1984) suggests a grouping criterion based on a firm's dividend behaviour, on the argument that severely cash constrained firms are more likely to pay low or no dividends.

I conduct two tests using this idea. Let β denote the response parameter of investment revisions to news in cash flow.

(i) <u>Test 1</u>: The investment response to news in cash flow in year t is larger if the firm pays no dividends in year t. This formulation is implied by a strict interpretation of a heirarchy of finance based on asymmetric information, where the firm uses neither equity nor debt to finance new investment (see Bond and Meghir, 1990). Let $\beta=\beta_0+\beta_1 Z$ where Z=1 if $Div_t=0$ and Z=0 otherwise. The null hypothesis is $\beta_1=0$, whereas under liquidity constraints $\beta_1>0$.

(ii) <u>Test 2</u>: The investment response to news in cash flow depends on the firm's dividend payout ratio (as in Fazzari, Hubbard and Petersen, 1988). Each firm is assigned to one of four groups, based on its average dividend payout ratio, D. Groups (denoted by g) are defined by the following intervals: $D<.1$, $.1\leq D<.2$, $.2\leq D<.4$ and $D\geq.4$. The null hypothesis is $\beta_g=\beta$ for all g. Under liquidity constraints, β_g should be larger for lower payout firms.[18]

A third test is based on the observation that a liquidity constrained firm should respond asymmetrically to good and bad news about cash flow. Any unconstrained optimal investment program must be characterised by an Euler condition relating the shadow prices of capital in two adjacent periods. This condition can be written $\lambda_t=\pi'_t+\delta(1-d)E(\lambda_{t+1}|\Omega_t)$ where λ, π', and d denote the shadow price, current marginal profitability, and depreciation rate of capital, respectively, and δ is the discount factor (for example, Bond and

Meghir, 1990). The unconstrained firm will respond to an unexpected change in cash flow by altering the investment profile so as to maintain this equality, and this holds symmetrically for windfall gains and losses. If the firm is liquidity constrained (in the sense that it cannot borrow on future cash flow either by issuing debt or equity), then the optimal investment program satisfies the modified Euler condition $\lambda_t=(1+\mu_t)\pi'_t+\delta(1-d)E(\lambda_{t+1}|\Omega_t)$, where μ_t denotes the shadow price of internal funds (Bond and Meghir, 1990). Hence the constrained shadow price of capital exceeds the unconstrained value if the liquidity constraint is binding. If this inequality did not hold, the firm would have an incentive to reallocate investment toward later periods. It follows that for the liquidity constrained firm negative news about cash flow will be fully reflected in a commensurate reduction in current investment, while good news will be spread over the entire investment profile to minimise deviations from the unconstrained program. This reasoning suggests the third test.

(iii) Test 3. Let $\beta=\beta_0+\beta_1 Z$ where Z=1 if $\pi_t<0$ and Z=0 otherwise. The null hypothesis is $\beta_1=0$, whereas under liquidity constraints $\beta_1>0$.

Table 6 summarises the test results for the liquidity constraints hypothesis (parameter estimates are not reported for brevity). The response of investment revisions to news in cash flow is not greater for firms that have lower dividend payout ratios or that pay zero dividends (see T1 and T2). Nor is there any evidence that firms respond more to negative news in cash flow than to positive news (see T3). For the two test statistics in the table that are statistically significant, the estimated parameters (not reported) violate the prediction of the liquidity constraints hypothesis. In short, there is no evidence for liquidity constraints in these data.[19] These results are somewhat surprising in view of the aforementioned, recent evidence supporting liquidity constraints in investment decisions. This study differs from previous research both in terms of methodology and data. The central methodological difference is that I relate revisions in investment plans to news in cash flow, whereas others relate actual investment expenditures to the level of cash flow. One possible reason for the differences in results is that the procedure to estimate the news in cash flow introduces measurement error that makes it difficult to detect the nonlinear responses implied by liquidity constraints. Furthermore, the panel data set used in this paper covers a longer and earlier time period than other recent studies, but it excludes the disruptive years following the major rises in the oil price during the 1970's. Whether these differences account for the divergent results remains an open question.

Concluding Remarks

This paper studies the empirical contribution of micro, sectoral and aggregate disturbances to the determination of investment plans and the stock market rate of return at the firm level. Survey data on investment plans of different horizons are used to construct investment revisions for a given target date. Under the assumption that the firm uses all relevant information in setting its optimal (value maximising) investment program, investment revisions and q serve direct measures (subject to measurement error) of the underlying disturbances in the forcing variables that determine investment and the value of the firm. A decomposition of the variance in, and covariance between, investment revisions and q reveals the relative contribution of micro, sectoral and aggregate disturbances.

The main empirical findings can be summarised succinctly. The dominant uncertainty in the investment decision is idiosyncratic. More than ninety percent of the variance in investment revisions is specific to the firm. Part of this micro variance reflects "measurement error", defined as variations in investment revisions that are not reflected in the stock market. Removing these measurement errors by analysing the covariance between revisions and q, however, does not change the main conclusion. More than two-thirds of the covariance between investment revisions and q is idiosyncratic and, if sectoral disturbances are included, the figure rises to about ninety percent. By contrast, common disturbances account for a full fifty percent of the variance in q, and most of this variance is due to purely macro shocks. The micro responses to common disturbances vary across firms. The degree of heterogeneity (measured by the coefficient of variation in the response parameter) is greater for investment revisions than for q. The presence of heterogeneity implies that micro effects of aggregate disturbances may be confounded with genuine micro shocks. The main conclusions are preserved, however, when an adjustment for heterogeneity is made. Idiosyncratic uncertainty remains dominant for investment revisions, but common disturbances are the primary determinant of q. Finally, the news in sales, factor prices, and cash flow are important determinants of revisions in investment plans and q at the firm level, accounting for about half of the covariance between investment revisions and q. However, there is no evidence to support the hypothesis that the effect of cash flow on investment revisions is due to liquidity constraints.

Taken as a whole, these results support the need to develop equilibrium models with heterogeneous agents and idiosyncratic uncertainty, and cast doubt on the descriptive relevance of representative agent models with aggregate uncertainty.

Endnotes

* An earlier version of this paper was presented at the NBER Summer Institute in Cambridge, Massachusetts. I have benefitted from the constructive criticisms and suggestions of the participants in that workshop and others. I would particularly like to thank Boyan Jovanovic, Ariel Pakes and Hugh Wills.

1. It is assumed that the value function satisfying equation (1) exists and that the associated optimal investment program is unique. For details of the necessary conditions, see Lucas and Prescott (1971).

2. This property characterises all revision processes under rational expectations. Revision processes (which are martingale difference sequences) have been used to characterise the set of solutions for linear rational expectations models by Broze, Gourieroux and Szafarz (1985).

3. In that case, of course, the value function in equation (1) must be modified to incoporate the liquidity constraint. The constrained optimal program is the sequence of investment plans that maximises the expected discounted value of net cash flows, subject to the constraint that planned investment expenditure is no larger than (expected) accumulated internal funds in each period. The orthogonality property in equation (5) is preserved if the value of $I_{t,k}$ reported by the firm corresponds to this constrained optimal investment profile.

4. For empirical applications of q, see Pakes (1985), Lach and Schankerman (1989), and Hall and Hayashi (1989).

5. Of course, this does not require that the forcing variables governing the

investment decision are themselves serially uncorrelated. The shocks are white noise because they represent news in the information set. They are mutually uncorrelated because of their nested structure - that is, the sectoral shock is defined as deviation around the common shock, and the micro shock as deviation around the sectoral shock.

6. The assumption is that the difference in the budgeting bias between two investment spans is common across firms, not that the bias for any given span is the same - i.e., firms differ proportionally in their degree of budgeting across spans. I do not include individual (fixed) firm constants because, given the highly unbalanced data set, it would be difficult to know whether individual firm means reflected $\phi_{ik}-\phi_{i,k+1}$ or the particular collection of years for which the firm appears in the sample.

7. Serial independence also does not depend on whether shocks have a permanent effect on the level of investment. To take an extreme example, suppose that profitability affects the optimal timing of investment but not its long run level (see Eisner, 1978). Then a firm's response to news about profits is to raise its current investment plans for some future periods and lower it for others. This would induce negative contemporaneous correlation among investment revisions of different spans, but not correlation in investment revisions over time.

8. The survey question was "How much do you now plan (in year t) to invest in new plants and equipment in (year t+1, t+2, t+3 and t+4)?". On the assumption that firms report investment plans in future (target date) prices, the reported $I_{t,k}$ is deflated by the price index for investment goods for year t+k. Deflating by current prices makes no difference to the empirical results.

9. The coverage varies by sector. The sample includes about 35 (33) percent of aggregate sales (investment) in manufacturing, but only 10 (16) percent in nonmanufacturing. Aggregate sales figures are taken from the Economic Report of the President, capital investment data from the Survey of Current Business.

10. Three remarks are in order. First, the mean revisions in Panel A provide estimates of the fraction of planned investment which is budgeted k years ahead, $s_k=\exp(\phi_k)$. Setting $s_0=1$, one obtains $s_1=1.04$, $s_2=0.86$, $s_3=0.74$, and $s_4=0.64$. These estimates seem plausible but I have no direct evidence to corroborate them. Second, most firms in the sample actually do exhibit zero means over time for investment revisions and q. The null hypothesis of zero mean is not rejected for between 65 and 85 percent of the firms, depending on the investment span. (Standard errors for individual firm means are valid in the presence of aggregate disturbances, not subject to the criticism of Keane and Runkle 1990). Third, the positive mean for q is consistent with an equity risk premium, though the sample mean is somewhat higher than the average premium in the U.S. during 1949-1973, about 7.1 percent.

11. The sector effects cannot be summarised adequately by a simple grouping into manufacturing durables, nondurables, and nonmanufacturing. To check this, each firm was assigned to one of these groups on the basis of its SIC number (from Compustat), and a variance decomposition was conducted for a three-way nested design that included a group variance component. The group component accounts for a negligible fraction of the variance in investment revisions and q, and the results reported in Panel A remain virtually unchanged.

12. In particular, identification requires strong assumptions on the covariances among measurement errors across different spans of investment

revisions (ϵ'', e" and u" in terms of the specification in equations (7) and (8)). This can be verified by writing out the covariance structure for the complete factor model with three spans of investment revisions and q, derived from equations (7) and (8).

13. Using equations (7)-(8), for example, the contemporaneous (total) covariance between investment revisions and q is $\sigma(yk,q) = \theta[\delta_0\sigma_\epsilon^2+\delta_1\sigma_e^2+\delta_2\sigma_u^2]$. This captures the variances of the news and the associated response parameters at each level of aggregation, but sweeps out the noise (namely, (ϵ',e',u') in q and (ϵ'',e",u") in yk).

14. Two points should be noted. First, the random coefficients approach assumes that the response parameters are uncorrelated with the realised shocks. This rules out cases where the firm responds discontinuously to a shock because of fixed costs of adjustment, as in Bertola and Caballero (1990). Second, the distribution of response parameters is assumed to be the same for all sectors in this analysis. The conclusions reached in this section are not sensitive to this second assumption. See note 16 for more discussion.

15. Using equation (10), the variance in investment revisions due to heterogeneous responses is $V_h = \sigma_\beta^2[\theta^2\epsilon_{jt}^2+(1-\theta)^2\epsilon_{j,t-1}^2]$. Since this variance is conditional on j and t, I consider the expected value $EV_h = A\sigma_\beta^2\sigma_\epsilon^2$ where $A=\theta^2+(1-\theta)^2$. The variance due to genuine micro shocks is $V_m^*=\sigma_v^2$, so the total measured micro variance is $V_m = V_m^*+EV_h$. Hence the fraction of the total variance in investment revisions due to genuine micro shocks can be written as $V_m^*/V_T=(V_m/V_T)-(\sigma_\beta/\bar{\beta})^2[1-V_m/V_T]$. A similar equation holds for the variance in q. For the covariance between investment revisions and q, the expression is $C_m^*/C_T=(C_M/C_T)-(\sigma_{\alpha\beta}/\bar{\alpha}\bar{\beta})[1-C_m/C_T]$.

16. Allowing the distribution of micro responses to differ across (broadly defined) sectors does not alter the main conclusions about the effects of heterogeneity. In particular, I allow both the second moments of micro shocks and the coefficient of variation in micro responses to differ between manufacturing durables, nondurables, and nonmanufacturing. This amounts to including both intercept and slope dummy variables for these sectors in equations (14)-(16). The intercept dummies are jointly insignificant in each equation for all investment spans. There are statistically significant differences in the slope dummies for the zero and second investment spans, but they have negligible effect on the variance and covariance decompositions reported in Tables 3 and 4.

17. Variations in average variable cost may reflect fluctuations in capacity utilisation rather than factor prices, if labor is a quasi-fixed input. I cannot distinguish between these hypotheses with the available data.

18. The number of firms (out of 273) in each dividend payout group is 13 in $D<.1$, 37 in $.1<D<.2$, 138 in $.2<D<.4$, and 85 in $D>.4$. An assignment based on the firm's average payout ratio may be sensitive to unusally good or bad earnings, since dividends are stable over time. Therefore, I also used an assignment rule requiring that at least 50 percent of a firm's dividend payout rates fall within a given interval. On this criterion 66 firms could not be assigned and were dropped (the distribution of firms across payout groups is very similar). The qualitative results for Test 2 are the same under both assignment rules.

19. This conclusion is reinforced by two supplementary tests. First, firms are segregated according to size rather than dividend payout ratio (first quartile in the distribution of sales served as the cutoff). This grouping

device is more consistent with a theory of a hierarchy of finance based on (fixed) transactions costs rather than asymmetric information. Second, the response parameter is allowed to differ in recession years (as identified by the NBER chronology of business cycles). Fazzari, Hubbard and Petersen have suggested that tight credit conditions in recessions may make firms more sensitive to internal funds. There is no significant difference in the response parameter to news in cash flow in either of these tests.

Table 1. Summary Statistics for Investment Revisions and q[a,b]

Panel A. General Statistics

	Obs	Firms	Mean	Median	Std Dev
y0	3424	142	−.040	−.078	.335
y1	2109	140	.195	.095	.508
y2	1952	130	.151	.041	.465
y3	1843	123	.137	.020	.466
q	4015	160	.093	.055	.322

Panel B. Correlations for Revisions[c]

	y0	y1	y2
y0	–		
y1	.259*	–	
y2	.197*	.543*	–
y3	.236*	.454*	.688*

Panel C. Autocorrelations for Revisions and q

	y0	y1	y2	y3
q	.072*	.173*	.152*	.130*
q_{-1}	.088*	.144*	.111*	.084*
q_{-2}	.011	−.013	.027	.011
q_{-3}	.011	.008	.009	−.022
q_{+1}	.052*	.009	.015	.010
q_{+2}	−.025	.067*	.015	.010
q_{+3}	−.013	.028	−.001	−.002
θ	.45	.55	.58	.61

Notes

[a] $yk_t = (I_{t,k}/I_{t-1,k+1})-1$ where $I_{t,k}$ is the plan for k years ahead reported in year t, deflated by the price index for investment goods in year t+k. $q_t = (P_t-P_{t-1}+Div_t)/P_{t-1})-r_t$ where P_t is the calendar year end stock price (adjusted for splits), Div_t denotes calendar year cash dividends, and r is the Aaa corporate bond rate.

[b] Observations where $|yk_t|>3.0$ have been dropped. These deletions constitute 0.4, 1.2, 1.2 and 1.5 percent of the sample for $y0_t$–$y3_t$ respectively. Correlations among revisions are robust to these deletions. Correlations of revisions with q are 150–250 percent larger after deletions, indicating outliers are badly contaminated.

[c] An asterisk denotes statistical significance at the 0.05 level.

Table 2. Decomposition of Investment Revisions and q[a]

Panel A. Variance Decomposition (%)

Component	y0	y1	y2	y3	q
Macro	1.9	4.3	3.0	2.2	37.2
Sector	2.5	6.0	4.6	0.9	13.4
Micro	95.6	89.7	92.4	96.9	49.4
T1[b]	2.4*	5.9*	3.7*	2.4*	101.9*
T2[c]	0.2	0.5	0.3	0.1	2.2*

Panel B. Covariance Decomposition (%)

Component	y0	y1	y2	y3
Macro	15.4	24.2	12.3	1.6
Sector	20.0	21.6	16.8	25.5
Micro	64.6	54.2	70.9	72.9
T1	29.9*	54.7*	19.4*	2.4*
T2	2.2*	2.7*	1.5*	2.1*

Notes

[a] The decompositions are based on the nested variance components design given by equations (7) and (8) in the text. Appendix 1 provides the estimation procedure.

[b] T1 denotes the F-test of the null hypothesis that there are no macro effects. In Panel A, H_o: $\sigma_\alpha^2=0$ for q and $\sigma_a^2=0$ for investment revisions. In Panel B, H_o: $\sigma_{a\alpha}=0$. An asterisk denotes rejection of H_o at the 0.01 significance level.

[c] T2 denotes the F-test of the null hypothesis that there are no sector effects. In Panel A, H_o: $\sigma_\beta^2=0$ for q and $\sigma_b^2=0$ for investment revisions. In Panel B, H_o: $\sigma_{b\beta}=0$.

Table 3. Heterogeneous Micro Responses to Macro Shocks: Investment Revisions and q[a]

Parameter	y0	y1	y2	y3	q
σ_u^2	.048	.169	.134	.162	.044
	(.008)	(.018)	(.019)	(.020)	(.005)
σ_β/β	1.65	1.04	1.19	1.08	0.64
	(.045)	(.059)	(.062)	(.098)	(.037)
r^2	.45	.23	.27	.11	.17
N	388	259	256	251	388
V_M/V_T(%)[b]	95.6	89.7	92.4	96.9	49.4
V_M^*/V_T(%)	83.6	78.6	81.6	93.3	28.7

Notes

a stimates are based on equations (14)-(15) in the text. Unweighted nonlinear least squares is used. Estimated standard errors are in parentheses.

b V_M/V_T is the percentage of sample variance due to micro effects (including heterogeneity), taken from Table 2, Panel A. V_M^*/V_T is the associated percentage excluding the effects of heterogeneity. See note 15 for details.

Table 4. Heterogeneous Micro Responses to Macro Shocks: Covariance Between Investment Revisions and q[a]

Parameter	y0	y1	y2	y3
σ_{uv}	.003	.001	.010	.008
	(.001)	(.003)	(.003)	(.003)
$\sigma_{\alpha\beta}/\bar{\alpha}\beta$	.025	.033	.146	.360
	(.029)	(.039)	(.043)	(.058)
r^2	.002	.003	.041	.125
N	414	271	269	266
C_M/C_T[b] (%)	64.6	54.2	70.9	72.9
C_M^*/C_T (%)	63.7	52.7	66.7	63.1
ρ[c]	.024	.050	.192	.521

Notes

[a] Estimates are based on equation (16) in the text. Ordinary least squares is used. Estimated standard errors are in parenthe least square

[b] C_M/C_T is the percentage of sample covariance between revisions and q due to micro effects (including heterogeneity), taken from Table 2, Panel B. C_M^*/C_T is the associated percentage excluding the effects of heterogeneity. See note 15 for details. [c] ρ is the correlation coefficient between the micro response parameters for investment revisions and q, computed as $\rho = \sigma_{\alpha\beta}/\sigma_\alpha\sigma_\beta$ using parameter estimates from Tables 3 and 4.

Table 5. Determinants of Investment Revisions and q[a]

Parameter	y0	y1	y2	y3	q
c	-.21	-.68	-.80	-.20	-.80
	(.24)	(.45)	(.42)	(.41)	(.20)
s	.50	.58	.62	.40	.08
	(.09)	(.18)	(.17)	(.16)	(.06)
Π	.014	.14	.12	.15	
	(.03)	(.05)	(.05)	(.05)	(.02)
c_{-1}					-.68
					(.19)
s_{-1}					-.18
					(.07)
Π_{-1}					.02
					(.03)
r^2	.027	.031	.04	.022	.080
N	1143	1173	1073	1024	1568
T1[b]	0.67	1.33	1.65	0.26	4.57
	(.67)	(.24)	(.13)	(.96)	(<.01)
T2	0.96	1.25	2.41	0.15	1.66
	(.41)	(.29)	(.07)	(.92)	(.17)
f(%)[c]	45.7	36.2	34.0	38.3	n.a.

Notes

[a] Year and sector-year dummies are included in the investment revision and q equations, respectively. The reported r^2 is net of their contribution. c, s, and Π refer to news in average variable cost, sales, and cash flow, estimated as residuals from a VAR(2) in (logs of) these variables, including year dummies.

[b] T1 tests the hypothesis that once and twice lagged values of c, s, and Π are jointly zero. T2 tests that twice lagged values are zero. The probability level is in parentheses. [c] f is the fraction of the (weighted) covariance between investment revisions and q accounted for by the innovations in c, s and Π. Letting $\tilde{yk}$ and $\tilde{q}$ denote residuals in the yk and q equations in Table 5, $f = 1 - \sigma(\tilde{yk}, \tilde{q})/\sigma(yk, q)$.

Table 6. Tests for Liquidity Constraints[a]

	y0	y1	y2	y3
T1: Zero Dividends	0.75 (.39)	4.44[b] (.04)	0.01 (.91)	1.08 (.30)
T2: Dividend Payout Groups	1.35 (.25)	1.98 (.11)	0.05 (.98)	0.54 (.66)
T3: Asymmetric Response	2.27 (.13)	5.29[b] (.02)	0.07 (.79)	0.71 (.40)

Notes

[a] The entries are computed F-test statistics. Probability values are in parentheses.

[b] The estimated response to Π violates the liquidity constraints hypothesis. For T1 the response to news in cash flow is smaller for zero-dividend firms. For T2 the response to negative news in cash flow is smaller than to positive news.

Appendix 1. Estimation of Variance and Covariance Components

Let y_{ijt} and q_{ijt} denote the investment revision (of some span) and the stock market rate of return for firm i in sector j in year t, respectively. The model incorporates an overall year effect, nested sector-year effects, and an idiosyncratic component. Formally,

$$y_{ijt} = m + \theta(a_t+b_{jt}+g_{ijt}) + (1-\theta)(a_{t-1}+b_{j,t-1}+g_{ij,t-1}) \tag{1}$$

$$q_{ijt} = \mu+\alpha_t+\beta_{jt}+\gamma_{ijt} \tag{2}$$

where m and μ are fixed constants, $(t-1,\ldots,A)$, $(j - 1,\ldots,B_t)$, and $(i - 1,\ldots n_{jt})$. Stochastic components are assumed to possess finite second moments, and to be independently and identically distributed and mutually independent except for $E(a_t\alpha_t)-\sigma_{a\alpha}$, $E(b_{jt}\beta_{jt})-\sigma_{b\beta}$ and $E(g_{ijt}\gamma_{ijt})-\sigma_{g\gamma}$. It is not required for estimation that components are normally distributed.

Consider first the estimation of the covariance components $\sigma_{a\alpha}$, $\sigma_{b\beta}$ and $\sigma_{g\gamma}$. Following the procedure for the analysis of variance with unbalanced data (Searle 1971), I equate the sample sum of cross products to their expected values and solve for the covariance components. Defining $B = \sum_t B_t$, $n_t = \sum_j n_{jt}$ and $n = \sum_t n_t$, and letting a subscripted dot represent summation over that index, equations (1) and (2) yield:

$$\begin{aligned} y_{\cdots} = nm + \theta\ (&\sum_t n_t a_t + \sum_j\sum_t n_{jt}b_{jt} + \sum_i\sum_j\sum_t g_{ijt}) \\ +(1-\theta)\ (&\sum_{t>1} n_{t-1}a_{t-1} + \sum_{t>1}\sum_j n_{j,t-1,}b_{j,t-1} + \sum_{t>1}\sum_i\sum_j g_{ij,t-1}) \end{aligned} \tag{3}$$

$$q_{\cdots} = n\mu + \sum_t n_t\alpha_t + \sum_j\sum_t n_{jt}\beta_{jt} + \sum_i\sum_j\sum_t \gamma_{ijt} \tag{4}$$

$$y_{t..} = n_t m + \theta(n_t a_t + \sum_j n_{jt} b_{jt} + \sum_i\sum_j g_{ijt}) + (1-\theta)\ (n_{t-1} a_{t-1} + \sum_j n_{j,t-1} b_{j,t-1} + \sum_i\sum_j g_{ij,t-1}) \tag{5}$$

$$q_{t..} = n_t \mu + n_t \alpha_t + \sum_j n_{jt} \beta_{jt} + \sum_i\sum_j \gamma_{ijt} \tag{6}$$

$$y_{.jt} = n_{jt} m + \theta(n_{jt} a_t + n_{jt} b_{jt} + \sum_i g_{ijt}) + (1-\theta)(n_{j,t-1} a_{t-1} + n_{j,t-1} + \sum_i g_{ij,t-1} \tag{7}$$

$$q_{.jt} = n_{jt}\mu + n_{jt}\beta_{jt} + \sum_i \gamma_{ijt} \tag{8}$$

Define the sample moments $T_0 = \sum_i\sum_j\sum_t y_{ijt}\, q_{ijt}$, $T_1 = y_{...} q_{...}/n$, $T_2 + \sum_t y_{t..} q_{t..}/n_t$ and $T_3 = \sum_j\sum_t y_{.jt}\, q_{.jt}/n_{.jt}$. Using equations (1)-(8), one obtains

$$E(T_0) = nm\mu + \theta n \sigma_{a\alpha} + \theta n \sigma_{b\beta} + \theta n \sigma_{g\gamma} \tag{9}$$

$$E(T_1) = nm\mu + \sigma_{a\alpha}\ (\sum_t n_t^2 - (1-\theta)\ n_A^2)/n + \sigma_{b\beta}\ (\sum_j\sum_t n_{jt}^2 - (1-\theta)\sum_j n_{jA}^2)/n + \sigma_{g\gamma}\ (1-(1-\theta)\,n_A/n) \tag{10}$$

$$E(T_2) = nm\mu + \theta n \sigma_{a\alpha} + \theta \sigma_{b\beta} \sum_j\sum_t (n_{jt}^2/n_t) + \theta A \sigma_{g\gamma} \tag{11}$$

$$E(T_3) = nm\mu + \theta n \sigma_{a\alpha} + \theta n \sigma_{b\beta} + \theta B \sigma_{g\gamma} \tag{12}$$

Equating the sample moments to their expected values in equations (9)-(12) and solving for the covariance components yields

$$\hat{\sigma}_{g\gamma} = (T_0 - T_3) \,/\, \theta(n-B) \tag{13}$$

$$\hat{\sigma}_{b\beta} = \frac{T_3 - T_2 - \theta(B-A)\ \hat{\sigma}_{g\gamma}}{\theta\ (n - \sum_j\sum_t (n_{jt}^2/n_t))} \tag{14}$$

$$\begin{aligned}\hat{\sigma}_{a\alpha} = {} & [T_2 - T_1 - \hat{\sigma}_{b\beta}\ \{\theta \sum_j\sum_t (n_{jt}^2/n_t) - \sum_j\sum_t n_{jt}^2/n + (1-\theta)\ \sum_j n_{jA}^2/n\} \\ & -\hat{\sigma}_{g\gamma}\ \{\theta A - 1 + (1-\theta)\,n_A/n\}] \ / \ [\theta n - \sum_t n_t^2/n + (1-\theta)\,n_A^2/n]\end{aligned} \tag{15}$$

The solutions in equations (13)-(15) require an external estimate of γ. From equations (1) and (2), a consistent estimator of $\hat{\theta} = \gamma/(1+\gamma)$ where $\gamma = \text{cov}(y,q)/\text{cov}(y,q_{-1})$. This estimator and equations (13)-(15) are used to estimate the covariance components in Panel B, Table 2 in the text.

The estimates of the variance components in Panel A, Table 2 are derived in an analogous manner. Computations for investment revisions are based on the following sample moments: $T_0 = \sum_i\sum_j\sum_t y_{ijt}^2$, $T_1 = y_{...}^2/n$, $T_2 = \sum_t y^2_{..t}/n_t$ and $T_3 = \sum_j\sum_t y^2_{.jt}/n_{.jt}$. These yield expressions analogous to equations (13)-(15) involving the variance components σ_a^2, σ_b^2 and σ_g^2. The same procedure holds for q with sample moments suitably defined, and yields the variance components σ_α^2, σ_β^2 and σ_γ^2. For computational simplicity, variance components are calculated by setting $\theta=1$. For investment revisions this is equivalent to defining the period t as June in year t-1 to June in year t. Since θ does not appear in the expression for q_t, the period refers to calendar year.

Appendix 2. Sectoral Composition of the Sample

	SIC Codes	# firms
Manufacturing		
Food, Tobacco	20-21	22
Textiles & Apparel	22-23	12
Lumber & Furniture	24-25	6
Paper & Printing	26-27	13
Chemicals & Drugs	28	25
Petroleum	13,29	17
Stone, Clay & Glass	32	11
Iron & Steel	33	31
Fabricated Metal Prod.	34	7
Nonelectrical Machinery	35	37
Electrical Machinery	36	11
Transport Equipment	37	22
Instruments	38	6
Miscellaneous	30,31,39	9
Nonmanufacturing		
Mining & Construction	10-16	8
Transportation Services	40-45	22
Communications & Public Utilities	48-49	33
Wholesale & Retail Trade	50-59	22
Finance and Insurance	60	4

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