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COLLECTION OF INFORMATION ABOUT
PUBLICLY TRADED FIRMS: THEORY AND EVIDENCE[*]

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WP# 1877-87   Revision of May 1988

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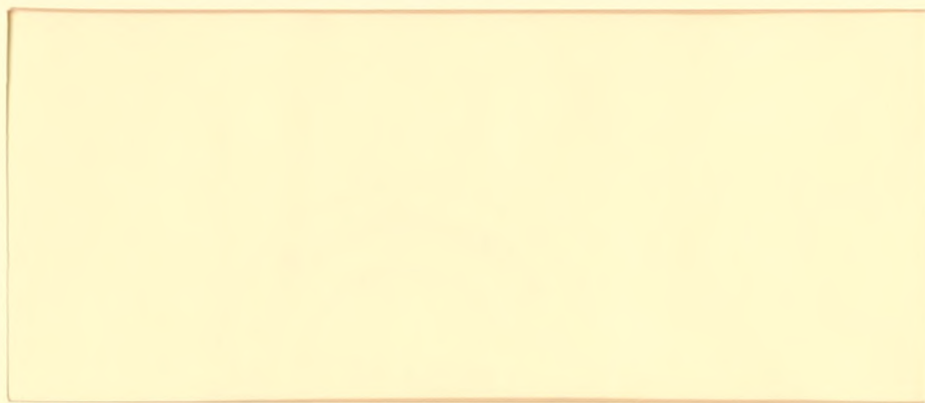Massachusetts Institute of Technology

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Abstract

This paper develops a model of information collection about publicly traded
firms in an economy. The supply noise is modeled as the variability of
liquidity-motivated trading in the shares of the firm. The paper
theoretically examines the influence of various firm characteristics on the
amount of information collected about a firm and on the marginal information
content of announcements made by it. Empirical work focuses on the marginal
information content of quarterly earnings announcements made by firms. The
empirical results are generally consistent with the model's predictions.

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1. INTRODUCTION

The motivation for this paper arises from the recently documented empirical regularity that security price reaction to an earnings announcement is a decreasing function of firm size.[1] This suggests that the security prices of larger firms are relatively more informative, thereby diminishing the impact of announcements by such firms. In this paper I develop an information collection model that examines the influence of various firm characteristics on the amount of information collected about a firm. I also try to formalize the notion of the marginal information content of an announcement and examine how various firm characteristics influence it. I then evaluate whether the above-mentioned empirical regularity is consistent with the model's predictions. Previous research in this area proves the existence of a noisy rational expectations equilibrium when information is costly.[2] However, in these papers the source of noise in the price system is exogenous, and is typically represented by uncertainty concerning the risky asset's per-capita supply. I model this noise as the variability of liquidity-motivated trading. This allows me to generate empirical predictions that are later tested.

In sections 2 and 3, I develop and analyze a single-period model. I define "supply noise" to be the variability of supply of a firm's shares. The model suggests that supply noise is positively related to the expected per capita trading volume (henceforth, trading volume) for a firm. Since firm size and trading volume are positively correlated, this suggests that supply noise increases with firm size. Verrecchia's result that the

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[1]See, for example, Richardson (1984), Ro (1984), Atiase (1985), and Freeman (1987).

[2]See, for example, Grossman (1976, 1978), Grossman and Stiglitz (1976, 1980), Hellwig (1980), Diamond and Verrecchia (1981), Holthausen and Verrecchia (1988), Verrecchia (1982), and Admati (1985).

informativeness of price varies inversely with the supply noise [Verrecchia (1982, Corollary 3, p. 1425)] then implies that informativeness of price should be inversely related to firm size. Unfortunately, this result is inconsistent with the empirical findings mentioned above. One way to reconcile this inconsistency is that although the informativeness of price system is inversely related to a firm's trading volume, a larger firm's price system may still be more informative if the marginal information collection cost is a decreasing function of firm size.

In section 4, I test the model's predictions. I regress marginal information content of quarterly earnings announcements on various firm-specific explanatory variables. This study is more comprehensive than previous studies in the following respects. First, I look at all four quarterly announcements in a year, while previous studies look at either annual [Richardson (1984), Ro (1984), and Freeman (1987)] or second quarter [Atiase (1985)] earnings announcements. Second, earlier studies focus either on firm size or on conducting univariate tests. Since size is correlated with the other explanatory variables (e.g., trading volume) it is possible that in these studies size may be capturing the effects of these other variables too. This problem is mitigated by studying the influence of the explanatory variables in a multiple regression context. Furthermore, in this paper, the explanatory variables include both firm size and trading volume. This approach separates the cost effects, using firm size as a proxy for the cost, from the benefit effects of information collection, using the dollar trading volume as a proxy for the benefit. This is in contrast to prior studies that use only firm size and thus cannot separate the two effects.

Empirical results are generally consistent with the theory. Marginal information content of earnings announcements increases with trading volume

and decreases with firm size. The latter result is consistent with the marginal cost of information collection being a decreasing function of firm size (or size acting as a proxy for other omitted variables). Finally, in section 5 I present some concluding remarks.

2. MODEL

2.1 DESCRIPTION OF THE MARKET

I develop a single-period model based on Verrecchia (1982). Consider an economy with one riskless bond and one risky asset (firm), both of which pay off in terms of the single consumption good in the economy at the end of the period. The numeraire in the market is the riskless bond. For each unit purchased, the bond pays off one unit and the risky asset $\tilde{u}$ units of consumption good at the end of the period. The pay-off $\tilde{u}$ on the risky asset is unknown until the end of the period with its realization denoted u.

In addition to the uncertainty about the return of the risky asset, the per-capita supply of the risky asset is noisy. The noise in the per-capita supply of the risky asset (hereafter, supply noise) results in the equilibrium price being a noisy aggregator of the total available information. I model supply noise as arising due to the liquidity-motivated trading in that asset. To characterize this idea more explicitly, assume there are two types of traders: liquidity traders and informed traders whose numbers are T and N respectively. I assume that only liquidity traders are endowed with the risky asset. Furthermore, I assume that the liquidity traders trade only for liquidity reasons, their demands are independent of the price of the risky asset and that they do not invest in information collection. The effect of assuming two classes of traders and making these assumptions is to make the liquidity demands (and hence supply noise from the point of view of informed traders) exogenous. This

helps to keep the model tractable and still permits modeling the supply noise as the variability of liquidity trading.

Assume that liquidity trader j supplies $\tilde{k}_j$ shares for liquidity reasons. The random variables $\tilde{k}_j$ are assumed to be independent and normally distributed with expected value zero and variance σ^2. Negative supply corresponds to excess liquidity; on average liquidity traders' net liquidity needs are zero.

Then $\tilde{X}$, the aggregate available supply of the risky asset is given by:

$$\tilde{X} = \tilde{k}_1 + \tilde{k}_2 + \ldots + \tilde{k}_T$$

and hence is normally distributed with expected value zero and variance $T\sigma^2$.

Each trader's prior beliefs about $\tilde{u}$ are that it has a normal distribution with mean y_0 and precision h_0. Before trading starts, some public information may also be available to the traders and these prior beliefs include the effect of any publicly available information about the firm.[3] The informed traders can acquire costly information before trading starts. This information entitles the informed trader t to observe a signal $\tilde{y}_t$ for the risky asset which communicates the true return $\tilde{u}$ perturbed by some noise $\tilde{\varepsilon}_t$:

$$\tilde{y}_t = \tilde{u} + \tilde{\varepsilon}_t$$

where $\tilde{\varepsilon}_t$ is a random variable which has a normal distribution with mean zero, precision $s_t > 0$, and which is independent of the perturbations of other traders. Each informed trader uses his observation along with what he can learn from the price to form posterior estimates of $\tilde{u}$.

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[3]In this paper, I model the public information released by the firm as an exogenous phenomenon. Diamond (1985) shows that this process can be made endogenous.

Several firm characteristics, including the prior precision, can affect the cost of information collection about a firm. The prior precision can influence the cost of information acquisition by affecting the amount of potential information that can be collected about the firm. Examples of some other firm characteristics that may influence cost of information acquisition are firm size and the degree of diversification of a firm. Large firms have many more sources of information than small firms. Large firms, on average, make more public releases than smaller firms, and are likely to be more dispersed geographically. All these factors may lead to information collection costs being different for large versus small firms. The degree of diversification of a firm may also influence the costs of acquiring information. For example, consider two firms: one in a single line of business and the other in many lines of business. For the firm in one line of business, information acquisition will be about one line of business only. However, for the firm in many lines of business, collection of information can be for one, two, or even all the firm's lines of business. The amount of information collected about a particular line will depend on the relative importance of that line for the firm as well as on the relative costs of information collection for the various lines.

Let Z_1, Z_2, ..., Z_n represent the various firm characteristics other than prior precision that affect the cost of information collection about the firm. The cost of acquiring a signal with precision s_t is represented by a continuous function $C(s_t, h_0, Z_1, ..., Z_n)$. I assume that as the precision of information s_t increases, collecting an additional unit of precision will require increased effort and cost. Thus, the cost function C is assumed to be strictly increasing and convex in s_t. Verrecchia (1982) notes that although this assumption is not necessary for the existence of an equilibrium, it does allow straightforward proof of the existence of an

equilibrium and appears to be a requirement for the closed form

characterization of the equilibrium derived here. I also assume that

$C_s(s_t, h_0, z_1, \ldots, z_n)$, the marginal cost of collecting an additional unit of

precision, is increasing in the level of the prior precision h_0. Thus,

$C_{sh_0}(s_t, h_0, z_1, \ldots, z_n)$ is also assumed positive.[4]

Each informed trader has a utility U for wealth w that is assumed to be

given by the negative exponential utility function:

$$U(w) = -\exp(-w/r)$$

where r is trader t's constant level of risk tolerance, assumed to be the

same for all the informed traders. The utility for wealth functions for

liquidity traders do not need to be characterized because as assumed earlier

their demands for the risky asset are exogenous (i.e., based only on their

liquidity needs) and do not depend on the price of the risky asset.

2.2 EQUILIBRIUM INFORMATION COLLECTION

To characterize the equilibrium information collection, I use results

from Verrecchia (1982). The similarities and differences between the two

models are as follows. In Verrecchia's model the cost of information

collection depends only on the level of precision; my cost function is more

general since the cost of information collection is a function of the level

of precision of information as well as several firm characteristics. In

Verrecchia's model, there is only one class of traders: they all have

rational expectations and the initial endowment of each trader is a random

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[4]A firm with low prior precision is assumed to have a proportionately
higher amount of potential information that can be collected about it.
Hence, collecting an additional unit of precision is going to be relatively
effortless for a firm having low prior precision. The marginal cost of
information collection is then lower for a firm with low prior precision,
i.e., $C_{sh_0} > 0$.

quantity which makes the aggregate supply of the risky asset random and exogenous. I model the randomness of the aggregate supply as arising out of the liquidity needs of traders by including another class of traders, liquidity traders, whose demands are independent of the price of the risky asset. Their role is therefore equivalent to making the aggregate supply exogenous and random as far as the informed traders are concerned. As a consequence, this model is essentially identical to Verrecchia's with respect to modeling the behavior of the informed traders.

Verrecchia's results can be directly applied to my model recognizing that the informed traders in my model are equivalent to the traders in Verrecchia's model. Thus, when Verrecchia defines V to be the variance of per-capita supply, "capita" should be interpreted as an informed trader in my model. In other words, let $\tilde{x}$ be the per-capita (where "capita" refers to an informed trader in my model) supply of the risky asset:

$$\tilde{x} \quad = \quad \frac{\tilde{X}}{N} \quad = \quad \frac{1}{N} \left[\tilde{k}_1 + \tilde{k}_2 + \ldots + \tilde{k}_T \right].$$

Then $\tilde{x}$ has mean zero and variance $(T/N^2)\sigma^2$. If I define V to equal $(T/N^2)\sigma^2$ then the two models become consistent and Verrecchia's results can be directly applied here.[5,6]

Under the above assumptions, equation (8) in Verrecchia (1982, p.1422)

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[5]In my model, the number of informed traders N and the number of liquidity traders T are exogenous so that their ratio is a constant. Thus, the variance of per capita supply when capita refers to any (informed or liquidity) trader, is a constant multiple of the variance of per-capita supply when capita refers to only an informed trader. Hence, the results derived in the paper hold equally well if the alternate definition (with capita referring to any trader) of per-capita supply is used. The reason for the chosen definition is to maintain consistency with Verrecchia's model.

[6]Since Verrecchia's results hold only when the number of traders in his model is large, the results derived here also hold only for the case when the number of informed traders is large.

can be used to obtain s^*, the optimal level of precision collected by an informed trader about the risky asset. Since all informed traders have the same level of risk tolerance here, that equation simplifies to:

$$s^* = \max\left[0, \ \hat{s} \ \left| \ \frac{2 \ C_s \ (\hat{s}, \ h_0, \ Z_1, \ \ldots, \ Z_n)}{r} \ \left[\ \hat{s} + h_0 + \frac{r^2 \hat{s}^2}{V} \right] \ = \ 1\right].\right. \tag{1}$$

Equation (1) implies that the optimal level of precision collected about the risky asset by all informed traders is the same. This happens because they all have the same degree of risk tolerance and face the same cost function.

Let S^* be the total precision about the risky asset that an informed trader acquires in equilibrium. Then S^* is given by:

$$S^* = h_0 + s^* + r^2 s^{*2}/V . \tag{2}$$

Equation (2) implies that the total precision that a trader acquires is the sum of the prior precision h_0, the precision of private information s^*, and an expression which is common to all traders, $r^2 s^{*2}/V$. The last expression, denoted Δ^*, represents the extent to which each informed trader benefits from the information acquisition activities of all others by conditioning his beliefs on price.

In the next section I examine the influence of various firm characteristics on the precision of private information collected about a firm and on the marginal information content of its announcements.

3. INFORMATION COLLECTION AND FIRM CHARACTERISTICS

I assume that there is a positive amount of information collected about the firm (i.e., s^* is non-zero). Henceforth, I drop the "*" to designate an equilibrium quantity. Then equation (1), which gives the optimal precision that each informed trader collects in equilibrium, can be rewritten as:

$$s + h_0 + r^2 s^2/V = r/[2C_s(s,h_0, Z_1, \ldots, Z_n)] . \qquad (3)$$

To study the influence of various firm characteristics on the precision of private information collected about the firm, I do comparative statics on equation (3).

3.1 EFFECT OF PRIOR PRECISION OF BELIEFS ON INFORMATION COLLECTION

The model indicates that, ceteris paribus, (1) the precision of private information decreases as the prior precision of beliefs increases; and (2) firms with higher prior precision of beliefs have higher marginal information content of announcements.

The partial derivative, $\partial s/\partial h_0$ or $s'(h_0)$, shows how the prior precision of beliefs influences s, the optimal level of precision of private information collected about the firm. The comparative static result from equation (3) (see Appendix A) is:

$$[1 + \frac{2\Delta}{s(h_0)} + \frac{rC_{ss}(s(h_0),h_0,Z_1,\ldots,Z_n)}{2C_s^2(s(h_0),h_0,Z_1,\ldots,Z_n)}]s'(h_0) = -1 - \frac{rC_{sh_0}(s(h_0),h_0,Z_1,\ldots,Z_n)}{2C_s^2(s(h_0),h_0,Z_1,\ldots,Z_n)} . \qquad (4)$$

Since the cost function is assumed to be strictly increasing and convex in s, it follows that the expression in square brackets on the left hand side of equation (4) is positive. Thus, the sign of $s'(h_0)$ depends on the sign of the right hand side. The first term on the right hand side of equation (4) is negative. The sign of the second term depends on the sign of $C_{sh_0}(s(h_0),h_0,Z_1,\ldots,Z_n)$, which is positive by assumption. Hence, $s'(h_0)$ is negative. Thus, ceteris paribus, a firm with higher prior precision of beliefs has less information collected about it. The optimal precision of information traders collect is obtained at the point where the marginal cost of collecting additional information is equal to the additional benefit provided by this information. An increase in prior

precision of beliefs results in an increase in the marginal cost and a decline in the additional benefit (since the additional benefit varies inversely with the total precision). Hence, the equilibrium private precision collected declines unambiguously. Both a reduction in the technological uncertainty about a firm's payoff or an increase in the amount of public information can lead to an increase in the prior precision of beliefs. One implication of this result is that increased availability of public information will lead to a decline in the amount of private information acquired about a security since the two are substitutes. A second implication is that a reduction in technological uncertainty about a firm's payoff will lead to a decline in the amount of information collected about the firm.

Another variable of interest is the effect of prior precision of beliefs on the marginal information content of the announcements made by the firm. In this single-period model, there is only one announcement and that is the declaration at the end of the period by the firm of the actual realization of the payoff. Thus, the announcement resolves all uncertainty about the payoff of the asset. The ratio, $\text{var}(\tilde{u}|y_t, P)/\text{var}(\tilde{u})$, denoted by M, can be used as a measure of the marginal information content of the announcement. Here, y_t and P refer to the private information of trader t and the price of the asset respectively. This quantity M is the fraction of the variance of $\tilde{u}$ that will be resolved by the announcement. The remaining fraction (1-M) is already impounded in price through the information acquisition activities of traders. Also note that M equals h_0/S, the ratio of the prior precision of beliefs to the total precision that traders acquire in equilibrium. Then from equation (2):

$$M = \frac{1}{1 + \frac{(s + r^2 s/V)}{h_0}} . \qquad (5)$$

As h_0 increases, s decreases, so that the term $(s + r^2 s/V)/h_0$ decreases with h_0 and M increases with h_0. An increase in prior precision of beliefs therefore results in an increase in the marginal information content of the announcement (M). As the prior precision of beliefs increases, there is less private information collected about the firm, which leaves more room for the announcement by the firm to have information content.

3.2 EFFECT OF TRADING VOLUME ON INFORMATION COLLECTION

The model suggests that ceteris paribus, firms with higher expected trading volume have higher precision of private information collected about them and have higher marginal information content of announcements. To derive this result, I first derive the relation between the unobservable variance of the per-capita supply and the expected trading volume, which is estimable.

As shown in Appendix B, in equilibrium the demand of the informed trader t for the risky asset, after he receives his private signal y_t and observes the market price P, is given by:

$$D_t (P, y_t) = r s \varepsilon_t + x . \qquad (6)$$

Equation (6) also gives the change in his holdings of the risky asset since the informed traders are not endowed with the risky asset. Using the above equation, the trading volume occurring in this market can be derived. The per-capita trading volume, denoted by Vol, is the sum of the absolute values of the changes in holdings of all traders (both informed and liquidity) divided by 2N:[7,8]

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[7]Pfleiderer (1982) also derives a similar expression for volume of trading. However, he ignores the volume of trading occurring within the liquidity sector which turns out to be important, as seen later.

$$\text{Vol} = \frac{1}{2N} \left[\sum_{t=1}^{N} | \ r \ s \ \varepsilon_t \ + \ x \ | \ \right] \ + \ \frac{1}{2N} \left[\sum_{j=1}^{T} |k_j | \right]. \qquad (7)$$

If Z is a normally distributed random variable with expected value zero and variance $\hat{\sigma}^2$, then the expected value and variance of $|Z|$ are $(2/\pi)^{1/2} \hat{\sigma}$ and $(1-2/\pi)\hat{\sigma}^2$. Using this fact and that V, the variance of per-capita supply is equal to $\frac{T}{N^2}\sigma^2$, the expected per-capita volume, denoted $\overline{\text{Vol}}$ is:

$$\overline{\text{Vol}} = \left[\frac{1}{2\pi} \ (r^2 s \ + \ V) \right]^{1/2} \ + \ \left[\frac{1}{2\pi} \ T \ V \ \right]^{1/2}. \qquad (8)$$

Comparative statics on equation (3) shows that as V increases, s must increase. Equation (8) then implies that expected per-capita volume increases as the variance of per-capita supply increases. This arises because an increase in V is equivalent to more trading by liquidity traders, which results in a higher expected volume. This increase in liquidity trading in turn makes the price system noisier and leads to an increase in trading by the informed traders, again increasing the expected volume.

Using equation (8), the unobservable variance V of per-capita supply can be written in terms of the other quantities that are observable or estimable. Unfortunately, there is no closed-form expression for V in terms of these other quantities. However, equation (8) can be rewritten as:

$$\overline{\text{Vol}} = \left[\frac{V}{2\pi} \ \right]^{1/2} \left[(\frac{r^2 s}{V} \ + \ 1)^{1/2} + T^{1/2} \ \right] \qquad (9)$$

which suggests that the expected per-capita volume $\overline{\text{Vol}}$ will be roughly proportional to $V^{1/2}$, the standard deviation of per-capita supply, either if

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[8]Same results hold if the alternate definition of capita (i.e., capita referring to any trader, either informed or liquidity) is used. The per-capita volume based on this alternate definition can be simply obtained by dividing the per-capita volume based on the definition used in the paper by a constant which is equal to (1+T/N).

$r^2 s/V \ll 1$, or if $(r^2 s/V + 1) \ll T$. This is likely to happen if one or more of the following conditions hold: (1) T, the number of uninformed traders in the market, is large, (2) the informed traders are very risk-averse, or (3) the precision of private information collected by them is small. If one or more of these conditions is satisfied, then $\overline{Vol}$ will be roughly proportional to $V^{1/2}$, i.e.:

$$V = \beta \ \overline{Vol}^2 \tag{10}$$

and the unobservable variance of the per-capita supply of the shares of a firm can be written in terms of the estimable expected trading volume in the firm. The results derived in this section are based on the approximation given in equation (10). However, only the results of this section (i.e., about the expected trading volume) are affected by this approximation.

To see how the expected trading volume in a firm influences s, I examine $\partial s / \partial \overline{Vol}$ or $s'(\overline{Vol})$. The arguments in the cost function are dropped for notational ease. Substituting $\beta \ \overline{Vol}^2$ for V in (3) and doing the comparative statics:

$$[1 + \frac{2\Delta}{s(\overline{Vol})} + \frac{rC_{ss}}{2C_s^2}]s'(\overline{Vol}) = \frac{2\Delta}{\overline{Vol}} \ . \tag{11}$$

Since the cost function is strictly increasing and convex in s, the terms in square brackets on the left hand side of equation (11) are positive. The sign of the right hand side is positive since both Δ and $\overline{Vol}$ are positive quantities. Hence, $s'(\overline{Vol})$ is positive. An increase in the expected trading volume in a firm is equivalent to an increase in supply noise. This has the effect of decreasing the total precision of informed traders and increasing the additional benefit from collecting private information. Since the marginal cost of information collection remains

unaffected, the equilibrium level of private information collected about the firm increases.

To study the impact of expected trading volume on the marginal information content of the announcement, recall that $M = h_0/S$. Using equation (3), M can be rewritten as:

$$M = \frac{2C_s(s,h_0,Z_1, \ldots, Z_n)h_0}{r} \qquad (12)$$

so that

$$\frac{r}{2h_0}[M'(\overline{Vol})] = C_{ss} \, s'(\overline{Vol}). \qquad (13)$$

Equation (13) shows that the sign of $M'(\overline{Vol})$ depends on the sign of $s'(\overline{Vol})$, since C_{ss} is positive by assumption. It was shown earlier that $s'(\overline{Vol})$ is positive, so $M'(\overline{Vol})$ is positive. This result implies that as the expected trading volume in a firm increases, the marginal information content of the announcement increases. An increase in the expected trading volume in a firm makes the price system noisier, i.e., causes the total precision to decline. This increases the benefit of collecting private information and leads to a higher level of private information collected about the firm. However, the precision of private information collected about the firm does not increase sufficiently (because the marginal cost increases with the level of the precision of private information) to counterbalance the decrease in the total precision caused by the increase in the expected trading volume. Thus the total precision acquired by the traders in equilibrium decreases, which implies that the marginal information content of the announcement increases.

3.3 EFFECT OF OTHER FIRM CHARACTERISTICS ON INFORMATION COLLECTION

Assume that a particular firm characteristic Z_i influences the cost function. To see how the characteristic Z_i influences s, $\partial s/\partial Z_i$ or

$s'(Z_i)$ is examined. Comparative statics on (3) yields:

$$[1+\frac{2\Delta}{s(Z_i)}+\frac{rC_{ss}(s(Z_i),h_0,Z_1,\ldots,Z_n)}{2C_s^2(s(Z_i),h_0,Z_1,\ldots,Z_n)}]s'(Z_i)= -\frac{rC_{sZ_i}(s(Z_i),h_0,Z_1,\ldots,Z_n)}{2C_s^2(s(Z_i),h_0,Z_1,\ldots,Z_n)} . \quad (14)$$

Equation (14) shows that the sign of $s'(Z_i)$ is opposite to that of C_{sZ_i}. Thus, $s'(Z_i)$ will be positive if C_{sZ_i} is negative. Using equation (5), it can also be shown that the sign of $M'(Z_i)$ is opposite to that of $s'(Z_i)$. An inverse relation between the marginal cost and Z_i leads to more private information collection about firms with higher values of Z_i and hence causes the announcements by these firms to have lower marginal information content.

3.4 SUMMARY

The model indicates that holding other factors constant, (1) firms with higher prior precision have less private information collected about them and have higher marginal information content of announcements, (2) firms with higher expected trading volume have more information collected about them and have higher marginal information content of announcements, and (3) other firm characteristics influence the amount of private information acquisition and the marginal information content of the announcements through their effect on the cost of information collection. It is difficult to explicitly characterize the dependence of the cost function on any particular firm characteristic. Hence, it becomes an empirical issue to study the influence of various firm characteristics on information acquisition about firms.

4. EMPIRICAL WORK:

4.1 MOTIVATION

The model developed and analyzed in sections 2 and 3 is a single-
period model and theoretical predictions are obtained about the precision of
private information collected about a firm and the marginal information
content of the announcement made by it. In this section I present some
empirical tests of the model. First, it is not possible to develop an
adequate empirical proxy for the precision of private information collected
about a firm. However, I argue in the following paragraphs that a
reasonable proxy can be developed for the marginal information content of
announcements made by firms. The empirical work deals with testing the
predictions relating to the marginal information content of announcements.

In the single-period model, the announcement by a firm resolves all
uncertainty about firm value. In a multi-period world, the counterpart to
that announcement is an earnings announcement, which resolves some, but not
all, uncertainty about firm value. Hence, a measure of the marginal
information content of the earnings announcements can be used as a proxy for
the marginal information content of the announcement in the single-period
model. I focus on quarterly earnings announcements.

The measure of the marginal information content of a quarterly earnings
announcement that I use can roughly be described as the ratio of an estimate
of the variance of the security's residual return on the announcement day
(the day of the quarterly earnings announcement) to the estimate of the
daily residual return variance estimated over both the announcement as well
as the non-announcement period.[9] Exactly how this measure is constructed is
discussed in section 4.2. In this section I motivate why such a measure is

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[9]A similar measure has also been used in previous studies [Beaver (1968)].

a reasonable proxy for the marginal information content of the announcement of the single-period model.

The marginal information content of the announcement in the single-period model is defined as the fraction of the variance of $\tilde{u}$ that is resolved by the announcement. Its multi-period analog would be the ratio of the variance of the change in value caused by a quarterly earnings announcement to the unconditional variance of the change in value resulting from quarterly earnings.

Instead of referring to this ratio as the ratio of the variances of the change in value, hereafter, I refer to it as the ratio of return variances since the two are equal and references to the latter are most common in the literature. The return variance associated with a quarterly earnings announcement can be approximated by an estimate of the security's residual return variance on the announcement day. To estimate the unconditional return variance associated with quarterly earnings, the variance should be estimated for the return over the whole quarter (i.e., over both non-announcement as well as announcement periods included in the quarter).[10] I assume that this variance is equal to the daily return variance estimated over a quarter times the number of trading days (approximately, 63) in the quarter.[11] The number of trading days in a quarter does not vary

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[10]Also note that this unconditional return variance is a reasonable proxy for var $(\tilde{u})$ or the inverse of prior precision, h_0, in the theoretical model. Low prior precision (or high var$(\tilde{u})$) implies a high degree of uncertainty about the liquidating dividend. This high uncertainty should in turn lead to a high unconditional return variance when this variance is estimated over the whole quarter (i.e., including both the non-announcement as well as the announcement periods) because the uncertainty has to unfold either through the information acquisition activity (i.e., over the non-announcement period) or through the announcement that the firm makes.

[11]This relation will be exact if the daily returns were independent, but there is plenty of evidence [e.g., French and Roll (1986)] that they are not. However, the magnitude of the serial correlation in daily returns is quite small and the assumption appears justified.

appreciably from quarter to quarter. Hence, the dependent variable in subsequent tests, the ratio of the estimated variance of a security's residual return on the announcement day to the security's estimated daily residual return variance for both the announcement and non-announcement periods, is a constant multiple of the marginal information content of a quarterly earnings announcement (with the constant being equal to the number of trading days in a quarter). Since the sign and significance of regression coefficients do not depend on the scaling of the dependent variable, an unscaled estimate is used.[12]

The empirical tests examine the influence of various firm characteristics on the marginal information content of earnings announcements. The firm characteristics examined are firm size, the expected trading volume in the firm, the prior precision of beliefs about the firm's return and the degree of diversification of the firm.[13] The next section provides the details on how proxies for all these variables were constructed.

4.2 DATA DESCRIPTION

For each firm in the sample, quarterly earnings announcement dates were collected from the Compustat tapes for the years 1977 through 1981, a maximum of twenty quarterly announcements per firm. To be included in the sample, a firm had to meet the following criteria: (1) be listed on the CRSP

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[12]Although theoretically, the marginal information content is bounded above by one, it need not be the case for the dependent variable which is a constant (greater than one) multiple of it. In fact, its expected value should be greater than one if a firm's announcement has any marginal information content. A mean value of the dependent variable greater than one would imply that more information comes to the market on announcement days (presumably through firms' announcements) than on average days.

[13]In the empirical work, I use a proxy for the inverse of prior precision rather than for the prior precision itself since, as argued above, an estimate of the daily residual return variance can be considered a suitable proxy for the inverse of prior precision.

daily return tapes for the period 1976-1982; (2) be on the Compustat tapes;
(3) have a December 31 fiscal year end; (4) have 4-digit SIC codes available
in the Standard and Poor's Register of Corporations and the Directory of
Corporate Affiliates. The first three criteria were applied for return and
financial data availability reasons. Criterion (4) was used to get data on
the firms' degrees of diversification. A total of 946 firms met the above
criteria and the criterion for the successful estimation of the market
model, which is discussed later.

Proxies for the marginal information content and the inverse of prior
precision were constructed for each firm and for every year in the study by
pooling data on all the four quarterly earnings announcements in that year
for the firm.[14] Let q_1, q_2, q_3, and q_4 denote the earnings announcement
dates for the first, second, third, and fourth quarters respectively for a
firm for a given year. Then the following two non-overlapping periods were
defined. Period (1): Days q_1 -39, q_1 -37, q_1 -35, ..., q_4 +19 (or q_4 +20);
and Period (2): Days q_1 -38, q_1 -36, q_1 -34, ..., q_4 +19 (or q_4 +20). This
gives a total of about 125-130 non-overlapping trading days for each
period. A firm with less than 100 days for either period was dropped from
the sample. The market model was used to eliminate the marketwide elements
of price changes:

$$\tilde{R}_{it} = \alpha_i + \beta_i \tilde{R}_{mt} + \tilde{\varepsilon}_{it}$$

where $\tilde{R}_{it}$ is the continuously compounded return for security i on day t,
$\tilde{R}_{mt}$ is the continuously compounded return for the value-weighted market
portfolio on day t and $\tilde{\varepsilon}_{it}$ is the stochastic idiosyncratic component of
$\tilde{R}_{it}$. Let a_i and b_i be the respective Scholes-Williams estimates of α_i and β_i

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[14]Pooling for a longer time period may be undesirable because of
potential non-stationarity in data.

over period 1.[15] The estimated coefficients a_i and b_i were used to compute e_{it}'s, the daily residuals, over both periods as follows:

$$e_{it} = R_{it} - (a_i + b_i R_{mt})$$

Let $\hat{\sigma}_{i1}^2$ and $\hat{\sigma}_{i2}^2$ be the estimates of σ_i^2, the variance of $\tilde{\varepsilon}_{it}$'s, over periods 1 and 2 respectively. Then since period 1 and period 2 do not have any days in common, the errors in $\hat{\sigma}_{i1}^2$ and $\hat{\sigma}_{i2}^2$ are uncorrelated and hence $\hat{\sigma}_{i1}^2$ and $\hat{\sigma}_{i2}^2$ are independent estimates of σ_i^2.

Residuals on days -1, 0, +1 are used to estimate $\hat{\sigma}_i^{*2}$, the announcement period residual return variance:[16]

$$\hat{\sigma}_i^{*2} = (1/12) \left[\sum_{t=1}^{t=4} \sum_{\tau=q_t-1}^{\tau=q_t+1} e_{i\tau}^2 \right] \tag{15}$$

The ratio of $\hat{\sigma}_i^{*2}$ to $\hat{\sigma}_{i1}^2$ is used as a measure of the marginal information content. This ratio is an estimate of the ratio of the return variance at quarterly earnings announcements to the unconditional return variance.

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[15]Tests were also conducted by estimating the market model parameters without using the Scholes-Williams correction and the results of those tests are very similar to those reported here.

[16]A preliminary examination of the data indicated that the price reaction was significant (at the 1% level) for all the three days -1, 0, and +1. Furthermore, for a sample of 1,866 report dates, comparing the Compustat date with the Wall Street Journal(WSJ) date, Penman (1987) found 38.4% on the same day, 49.2% one day prior to WSJ date, 1.4% more than one day before WSJ date, 8.7% one day after WSJ date and 2.2% more than one day after. This evidence indicates that the window of $\pm$ 1 days around the Compustat date is very likely to capture the actual announcement date.

$\hat{\sigma}_{i2}^{2}$ is used as a proxy for the inverse of prior precision.[17]

In section 3, results were derived in terms of the per-capita expected trading volume where capita could refer to either all informed traders or both informed and uninformed traders (since their numbers were fixed) in the economy. I use total dollar trading volume instead of per-capita dollar volume since the latter is just a constant (one over the total number of traders in the economy) times the former and hence regression coefficients will get affected by only a constant. The proxy for the expected dollar trading volume is the dollar trading volume in the firm in the previous year. This is obtained by multiplying the year-end closing price by the number of shares traded during that year as reported on the Compustat tapes.[18]

Firm size and the degree of diversification of a firm are likely to affect the marginal information content of earnings announcements made by a firm through their influence on the cost of information collection about the firm. These variables are therefore also included as explanatory variables in the regression. The proxy chosen for firm size is the market value of the equity outstanding on the last trading day of the previous year,

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[17]Constructing and using the variables in this way eliminates any spurious correlation between the dependent variable and the explanatory variable since $\hat{\sigma}_{i1}^{2}$ and $\hat{\sigma}_{i2}^{2}$ are independent estimates of the same quantity, the residual return variance. Furthermore, if the announcement period falls outside the estimation period, then any non-stationarity in data can also result in spurious negative correlation between the dependent variable and the independent variable $\hat{\sigma}_{i2}^{2}$. Here, by construction, the announcement period as well as the non-announcement period are part of the estimation period, which eliminates this problem.

[18]The tests reported here were repeated using another proxy for the total dollar volume of trading obtained by multiplying the average of the prices at the beginning and the end of the year with the number of shares traded during the year and the results were very similar to those reported.

obtained from the Compustat tapes. Ideally, the proxy for the degree of diversification should be a value-weighted average of the number of lines of business of a firm. However, the only data available were on the number of 3-digit or 4-digit SIC codes associated with a firm. As a compromise, three different proxies were chosen for the degree of diversification: (1) the number of 4-digit SIC codes for the firm appearing in the Standard and Poor's Register of Corporation, (2) the number of 4-digit SIC codes listed in the Directory of Corporate Affiliates, and (3) the number of 3-digit SIC codes listed in the Directory of Corporate Affiliates. These proxies were denoted LOB1, LOB2, and LOB3 respectively. None of the three proxies takes into account correlations among the firm's lines of business, although these correlations are also likely to influence the amount of information collected about a firm.

4.3 RESULTS

Panel A of Table 1 reports deciles of estimated marginal information content, M. Its mean is 1.36. The median is 1.11 and about 55% of the firms in the sample have M greater than 1.00. Panel B of Table 1 provides the descriptive statistics for M for each of the years 1977 through 1981 covered by the study. For each year the mean and the median values for the marginal information content are greater than one. These results indicate that on quarterly earnings announcement days more information comes to the market (presumably through the earnings announcements) than on average days. Also from panel B there is no indication of any strong pattern in the behavior of the marginal information content variable from year to year.

Table 2 provides descriptive statistics on the variables used in the regression. The firms in the sample are relatively large: the median firm has $164 million in equity outstanding and the median yearly trading volume

is $45 million. The LOB statistics reveal that the median number of 4-digit codes associated with a firm is four.

There may be important industry differences across firms in terms of private information acquisition. The cost functions governing information collection may be different across different industries or there may be systematic differences across industries in the impact the earnings announcements have on firm value. This may lead to differences across industries in the marginal information content of earnings announcements. To control for these industry differences, firms were classified into six separate industries on the basis of their primary line of business. The industry groups (2-digit SIC codes in parentheses) were: (1) Mining (10-14), (2) Construction and Manufacturing (15-39), (3) Transportation, Communication and Other Public Utilities (40-49), (4) Wholesale and Retail Trade (50-59), (5) Finance, Insurance, and Real Estate (60-67), and (6) Services (70-96). The number of firms in the six industry groups were 62, 544, 156, 42, 99, and 43 respectively.

Ordinary Least Squares (OLS) regressions were run with the marginal information content of earnings announcement as the dependent variable and proxies for the various firm characteristics as the explanatory variables.[19] The approach chosen to control for industry differences was to use dummy variables for the six industry groups in the regression. Initially, the regression specification used was:

$$M(i) = b_0 + b_1 Ln[(value)(i)] + b_2 Ln[(volume)(i)] + b_3 \hat{\sigma}^2_{i2}$$

$$+ b_4 \text{Proxy for the degree of diversification } (i) + \sum_{j=1}^{5} \delta_j I_j(i) + e(i),$$

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[19]Cross-sectional dependence is not expected to be a serious problem here since announcement dates are not common across firms and I am working with daily data.

where M(i) stands for the marginal information content of earnings announcement and I_j's are dummy variables for the respective industry categories with the effect of the sixth category, I_6 (Services) being captured in the constant b_0.[20] Logs of the value and volume variables were used because both these variables are highly right-skewed. The diagnostic checks of this regression indicated that the fitted model generated a few positive outliers and the residuals from the regression did not appear to be normally distributed and were skewed to the right. To reduce the effect of skewness on test results, the regression was reestimated with ln[M(i)] as the dependent variable. The diagnostic checks of this regression indicated no apparent violations of the OLS regression assumptions and the residuals from the regression appeared to be normally distributed.[21]

Table 3 reports the results of this regression for the whole five-year period with LOB1 as the proxy for the degree of diversification.[22,23] The

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[20]Unexpected earnings was not used as an explanatory variable in this regression. This was because the dependent variable used in the paper and (a properly scaled) square of unexpected earnings are both proxies for the marginal information content of earnings announcements. Including unexpected earnings (or a transformation of it) as an explanatory variable would result in misspecification in the estimated regression and would bias the estimated coefficients of other explanatory variables. A variable derived from unexpected earnings can be used as an alternate dependent variable. However, lack of exact correspondence between accounting earnings and economic earnings and between the value of a firm and its current economic earnings will make it a noisier proxy for marginal information content than the ratio of the estimated return variances.

[21]A Kolmogorov-Smirnov goodness of fit test to check the normality of the residuals from the regression generated a statistic of 0.97 with a 2-tailed p-value of 0.30.

[22]A regression was also estimated using log transformations of the dependent variable as well as all the independent variables (other than the dummy variables). The results of this regression as well as those of the original regression (i.e., using M(i) as the dependent variable) lead to similar set of inferences as those reported here.

results are not sensitive to the choice of the proxy used for the degree of diversification and similar results were obtained when LOB2 and LOB3 were used as proxies for the degree of diversification. The estimated coefficient on ln(value) is significantly negative at the 1% level while the estimated coefficient on ln(volume) is significantly positive at the 1% level. The estimated coefficient of $\hat{\sigma}_{i2}^2$ is negative with a t-statistic of -1.10 and the LOB variable has a t-statistic close to zero.

The observed sign on the coefficient of ln(volume) is consistent with the model's predictions in section 3. There it was argued that an increase in trading volume makes the price system noisier so that the benefit from information acquisition goes up and hence more private information is collected about the asset, but this increased acquisition of private information does not completely counteract the effect of the increased noise in the price system and hence the marginal information content of the announcement increases with trading volume.

The negative sign on the coefficient of ln(value) is consistent with the hypothesis that the marginal cost of information collection decreases as firm size increases. Another interpretation is that firm size proxies for other omitted variables (e.g., the amount of publicly available information) and the combined effect of all these other variables on the marginal information content of announcements is negative.

Analysis of section 3 predicts that earnings announcements convey less information for firms with lower prior precision (or higher variance of residual return). Higher variance of residual return leads to more private

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[23]Regressions were also estimated for each year separately. The results were similar to those reported in table 3 for the pooled five-year period.

information collected about the firm, resulting in the firm's announcements having lower marginal information content. Thus, a negative sign is predicted on the coefficient of $\hat{\sigma}_{12}^2$. However, the coefficient is not significant. A likely explanation is that $\hat{\sigma}_{12}^2$ estimates residual return variance with error. The errors-in-variable (assuming that the error is uncorrelated with the other explanatory variables, which is likely to be the case) will attenuate this coefficient, consequently lowering its t-statistic.

The coefficient of the LOB variable is also insignificantly different from zero. This result suggests that the degree of diversification does not significantly affect the marginal information content of earnings announcements. One possible explanation is that proxies chosen do not adequately measure the extent of diversification of a firm.

A partial F-test to check for the significance of the industry dummy variables as a group yielded an F-statistic of 5.17, which is significant at the 1% level, indicating that the industry dummy variables add to the explanatory power of the model. This implies that there are differences across industries in the marginal information content of earnings announcements. These could result from differences across industries in cost functions governing the information collection or from systematic differences across industries in the impact of earnings announcements on the value of a firm.

In general, with such a large number of observations, any model misspecification can generate statistically significant coefficients. For example, the market model used to compute the residuals may be misspecified and the misspecification systematically related to one or more of the explanatory variables. Then the estimated coefficients can be different from zero under the null hypothesis of no effect of the explanatory

variables. Similarly, in the calculation of M, the numerator is estimated with many fewer observations than the denominator. This procedure may introduce a systematic bias in the estimated coefficients if, for example, there are correlated measurement errors in returns. To examine whether the observed empirical relation is spurious, the above regressions were repeated over non-announcement period. A procedure similar to that used for calculating the marginal information content during the announcement period was employed. Squared residuals were averaged across each three-day window starting from day -10 up to day +10 for all the four quarters. Thus, the first window covers days -10 to -8 and the last one from days +8 to +10. Choosing three-day windows during the non-announcement period makes the non-announcement period results directly comparable with those for the announcement period.

The results (not reported) of these regressions indicated that for all of the windows, most of the observed coefficients associated with the various explanatory variables were insignificantly different from zero and the significant ones had signs opposite to those observed for the announcement period regression. These results suggest that the earlier findings are not a consequence of model misspecification. Specifically, the approach adopted to take care of the spurious negative dependence between the dependent variable and the explanatory variable, $\hat{\sigma}^2_{i2}$, seems to have been successful.

5. CONCLUSIONS

Recent studies have documented that the marginal information content of earnings announcements is related to firm size. This motivated me to examine the information collection process about publicly traded firms theoretically and empirically.

I modeled the noise in the price system as the variability of liquidity-motivated trading in the shares of a firm and argued that this noise is positively related to the expected trading volume in the firm. The model indicated that, holding other factors constant, (1) firms with higher prior precision have less private information collected about them and have higher marginal information content of announcements, (2) firms with higher expected trading volume have more information collected about them and have higher marginal information content of announcements and (3) other firm characteristics, like size and the degree of diversification, influence the amount of private information acquisition and the marginal information content of the announcements through their effect on the cost of information collection.

In the empirical tests, I examined the dependence of the marginal information content of earnings announcements on various firm characteristics. The marginal information content of earnings announcements decreases with an increase in firm size and increases as the dollar trading volume in the firm increases. The result on trading volume is consistent with the model's predictions and the inverse relation between firm size and the marginal information content of the earnings announcements is consistent with the marginal cost of information collection being a decreasing function of firm size or firm size acting as a proxy for other omitted variables whose combined effect on the marginal information content of announcements is negative.

In this paper, I defined marginal information content of announcements in terms of their impact on the value of the firm and hence worked with security returns. I did not examine the price-earnings relation, which is clearly a related topic. Future studies can do a more careful and formal analysis of the link between the information collection process and the

price-earnings relation and utilize the theoretical and empirical work of
this paper in improving our understanding of this relation. I also hope
that studies examining the performance of or explaining the cross-sectional
properties of alternate proxies for expected or unexpected earnings can also
benefit from this paper.

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TABLE 1

DATA ON MARGINAL INFORMATION CONTENT, M[a]

PANEL A: DECILES FOR MARGINAL INFORMATION CONTENT

Decile	M
0.1	0.493
0.2	0.668
0.3	0.802
0.4	0.949
0.5	1.107
0.6	1.288
0.7	1.520
0.8	1.856
0.9	2.470

PANEL B: DESCRIPTIVE STATISTICS FOR MARGINAL INFORMATION CONTENT FOR EACH YEAR OVER THE PERIOD 1977-1981

YEAR	N	MEAN	MEDIAN	STD. DEV.	MIN.	MAX.
1977	902	1.51	1.20	1.48	0.11	25.2
1978	917	1.44	1.22	0.91	0.07	8.00
1979	925	1.33	1.09	1.02	0.14	12.42
1980	933	1.21	1.01	0.85	0.09	7.74
1981	938	1.31	1.04	1.07	0.08	12.70

[a]The marginal information content, M, is defined as the ratio of estimated variance of daily residuals during the quarterly earnings announcement period to estimated variance of daily residuals during the estimation period (which includes both the announcement as well as the non-announcement periods). It is thus a relative measure of the amount of information revealed by the announcement.

The total number of observations on M is 4615 (946 firms and up to 5 years of data on each) and the time period spanned by the study is 1977-81.

TABLE 2

DESCRIPTIVE STATISTICS OF THE DATA USED IN THE REGRESSIONS

OF MARGINAL INFORMATION CONTENT[a]

VARIABLE	MEAN	MEDIAN	STD. DEV.	MIN.	MAX.
MARGINAL INFO. CONTENT, M	1.36	1.11	1.09	0.07	25.2
VALUE ($ 000's)	647726.0	163721.2	2075080.0	570.0	43524248.0
LN(VALUE)	11.88	12.01	1.84	6.35	17.59
VOLUME ($ 000's)	189165.4	45359.6	463394.3	83.2	9456651.0
LN(VOLUME)	10.54	10.72	2.05	4.42	16.06
$\hat{\sigma}^2_{12}$	0.000535	0.000326	0.000630	0.000027	0.00937
LOB1	5.40	4.00	5.51	1.0	41.0
LOB2	4.40	4.00	3.27	1.0	22.0
LOB3	3.87	3.00	2.72	1.0	18.0

[a]The marginal information content, M, is defined as the ratio of estimated variance of daily residuals during the quarterly earnings announcement period to estimated variance of daily residuals during the estimation period (which includes both the announcement as well as the non-announcement periods).

VALUE is the market value of equity at the end of previous year.

VOLUME is the dollar trading volume in the previous year.

$\hat{\sigma}^2_{12}$ is an estimate of the residual return variance.

LOB1, LOB2, and LOB3 are three alternate proxies for the degree of diversification of the firm.

The number of observations on each variable is 4615 (946 firms and up to 5 years of data on each) and the time period spanned by the study is 1977-81.

TABLE 3

REGRESSION RESULTS FOR THE MARGINAL INFORMATION CONTENT OF EARNINGS ANNOUNCEMENTS[a]

$$LN[M(i)] = b_0 + b_1 LN[Value(i)] + b_2 LN[Volume(i)] + b_3 \hat{\sigma}_{i2}^2$$
$$+ b_4[LOB1(i)] + \Sigma_{j=1}^{5} \delta_j I_j(i) + e(i),$$

Independent Variable	Coefficient (t-statistic)
Constant	0.484 (5.33)
Ln(Value)	-0.060 (-4.01)
Ln(Volume)	0.031 (2.45)
$\hat{\sigma}_{i2}^2$	-20.15 (-1.10)
LOB1	-0.0003 (-0.14)
I_1 (Mining)	-0.071 (-1.25)
I_2 (Const. and Mnfg.)	0.045 (1.01)
I_3 (Utilities)	-0.077 (-1.54)
I_4 (Wholesale and Retail Trade)	0.072 (1.17)
I_5 (Financial Institutions)[b]	-0.019 (-0.36)
Adjusted R-squared	0.013
F-stat.[c]	7.80

[a]See Table 2 for variable definitions. The number of observations for the regression is 4615.

[b]The effect of the sixth category, I_6 (Services) is captured in the constant b_0.

[c]F-stat. is significant at the 1% level.

Appendix A: Derivation of Equation (4)

The comparative static result from equation (3) is:

$$s'(h_0) + 1 + \frac{r^2}{V} [2s(h_0)s'(h_0)] =$$

$$\frac{-r[C_{ss}(s(h_0),h_0,z_1,\ldots,z_n)s'(h_0) + C_{sh_0}(s(h_0),h_0,z_1,\ldots,z_n)]}{2\, C_s^2(s(h_0),h_0,z_1,\ldots,z_n)} \quad .$$

Recall that the term r^2s^2/V is the informativeness of the price system, Δ. Substituting Δ for r^2s^2/V and simplifying,

$$s'(h_0) + 1 + \frac{2s'(h_0)\Delta}{s(h_0)} =$$

$$\frac{-r[C_{ss}(s(h_0),h_0,z_1,\ldots,z_n)s'(h_0) + C_{sh_0}(s(h_0),h_0,z_1,\ldots,z_n)]}{2\, C_s^2(s(h_0),h_0,z_1,\ldots,z_n)} \quad .$$

Rearranging terms,

$$\left[1+\frac{2\Delta}{s(h_0)}+\frac{rC_{ss}(s(h_0),h_0,z_1,\ldots,z_n)}{2C_s^2(s(h_0),h_0,z_1,\ldots,z_n)}\right]s'(h_0)= -1 - \frac{rC_{sh_0}(s(h_0),h_0,z_1,\ldots,z_n)}{2C_s^2(s(h_0),h_0,z_1,\ldots,z_n)}$$

which is equation (4). The derivations of equations (11) and (14) are also straightforward and similar to that of equation (4).

Appendix B: Derivation of Equation (6)

It can be shown that the price $\tilde{P}$ of the risky asset is given by [see equation (1), Verrecchia, 1982 (henceforth V'82)]:

$$\tilde{P} = \alpha y_0 + \beta \tilde{u} - \gamma \tilde{x} \tag{B1}$$

where α, β, and γ are given by equation (2) in V'82 and for the special case considered in this paper of the same risk tolerance r for all informed

traders, those expressions simplify to:

$$\alpha = \frac{h_0}{S} \ , \quad \beta = 1 + \frac{r^2 s}{V} \ , \text{ and } \quad \gamma = \frac{V + r^2 s}{rVS} \ . \tag{B2}$$

Let μ_t be the mean of u conditional on trader t observing $\tilde{y}_t = y_t$, and $\tilde{P} = P$ respectively. Then using equations (3) and (4) in V'82, μ_t is given by:

$$\mu_t(y_t, P) = y_0 + \frac{s(y_t - y_0)}{S} + \frac{\beta(P - y_0)}{\gamma^2 VS} \ . \tag{B3}$$

Also, using equation (5) in V'82, the demand $D_t(P, y_t)$ of the informed trader t for the risky asset can be written as:

$$D_t(P, y_t) = rS(\mu_t - P) \ . \tag{B4}$$

Substituting for P and μ_t from equations (B1) and (B3) and $u + \varepsilon_t$ for y_t in (B4),

$$D_t(P, y_t) = rS[y_0 + \frac{s(u + \varepsilon_t - y_0)}{S} + (\frac{\beta}{\gamma^2 VS} - 1)(\alpha y_0 + \beta u - \gamma x) - \frac{\beta y_0}{\gamma^2 VS}] \tag{B5}$$

or,

$$D_t(P, y_t) =$$

$$[rS - rs + r(\frac{\beta}{\gamma^2 V} - S)\alpha - \frac{r\beta}{\gamma^2 V}]y_0 + [rs + \frac{r\beta^2}{\gamma^2 V} - rS\beta]u - [\gamma(\frac{r\beta}{\gamma^2 V} - rS)]x + rs\varepsilon_t. \tag{B6}$$

Substituting for α, β, and γ from equation (B2) in (B6) and doing some algebra, it is straightforward to show that the terms in square brackets preceding both y_0 and u sum to zero and those preceding x sum to one, so that

$$D_t(P, y_t) = x + rs\varepsilon_t \tag{B7}$$

which is same as equation (6) in the text.

Date Due