5 The Real Output of the Stock Exchange

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> A stock analyst, unhappy with his job, went to lunch with an officer of a competing pension fund. The analyst made his case carefully, explaining which of his material was being ignored, and what lesser material from others was guiding actual trading. The officer, who had no intention of hiring the analyst, picked up the check. Who paid for the lunch?

Over the last three decades, trading on stock exchanges has been growing at a growing rate. In 1960, 958 million shares of stock were traded on the New York Stock Exchange (NYSE). By 1970, this had roughly tripled to 3,124 million. By 1987, the volume had grown another 15-fold to 48,144 million shares, and the NYSE was planning for a potential billion-share *day* by the early 1990s.[1] This pattern of accelerating growth is even stronger on the newer exchanges on which the shares of smaller firms are traded. The volume on NASDAQ grew from 1,390 million shares traded in 1975 to 37,890 million in 1987. The acceleration is even more marked if we consider the recent growth in stocklike instruments such as options.

A trade of a share of stock is not a constant unit.[2] In figure 5.1, we show the growth in the deflated dollar value of trades on U.S. securities markets. The line labeled "stocks" is the total market value of trades on all the stock

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1. For recent stock-exchange data on the NYSE and the NASDAQ, see the 1989 *Statistical Abstract of the United States*, tables 830 and 831. The 1960 number is taken from the 1961 U.S. Securities and Exchange Commission *Annual Report*, table 9, p. 219.

2. Stock splitting behavior tends to keep the nominal value of the average share traded roughly constant in the intermediate run.

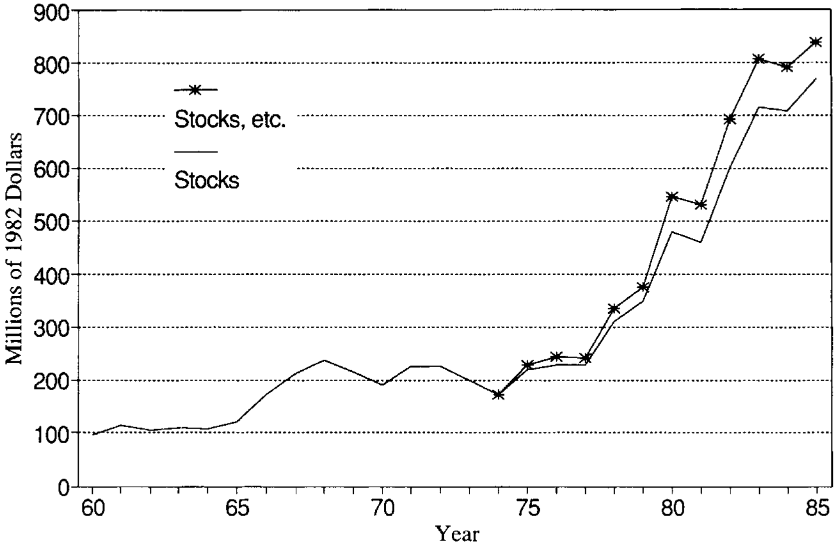

Fig. 5.1 Dollar (millions) volume of trading (deflated to 1982 by Standard and Poor's 500 index)

exchanges registered with the Securities and Exchange Commission.[3] The line labeled "stocks, etc." includes nonstock securities; warrants, rights, equity options (whether traded or exercised) and trades in nonequity options. The deflator for the figure is an extremely conservative one, the value of the Standard and Poor's 500 portfolio over time.[4] Clearly, the figure shows a dramatic change in the rate of growth of trading, partly driven by the expansion in nonstock but equitylike securities. Overall, the rate of growth of trades in the figure is 8 percent per annum, but the later periods clearly show more rapid growth. If we were to use a less conservative deflator for the figure, such as the GNP deflator, it would show an even more dramatic acceleration.

The growth in trading was accompanied by rapid growth in inputs at stock exchange member firms. Figure 5.2 displays selected inputs into NYSE member firms for the period beginning in 1971.[5] The solid line shows total expenditures in 1987 dollars, using the GNP deflator. The line with asterisks shows registered representatives, that is, broker personnel. (This series is not available for 1984). This period of rapid trading growth was also a period of rapid growth in the resources consumed by the sector. These resources primarily

3. See, e.g., table 18A of the 1986 U.S. Securities and Exchange Commission *Annual Report*, col. 2, and corresponding tables in earlier annual reports.

4. The advantage of this deflator is that it standardizes the unit of traded stock to remove the problems associated with stock splitting, etc. It overdeflates because the real rate of interest is built into stock returns in the long run.

5. For 1971–83, the data come from the annual NYSE *Fact Book*, later, from the Securities Industry Association, *Securities Industry Yearbook*.

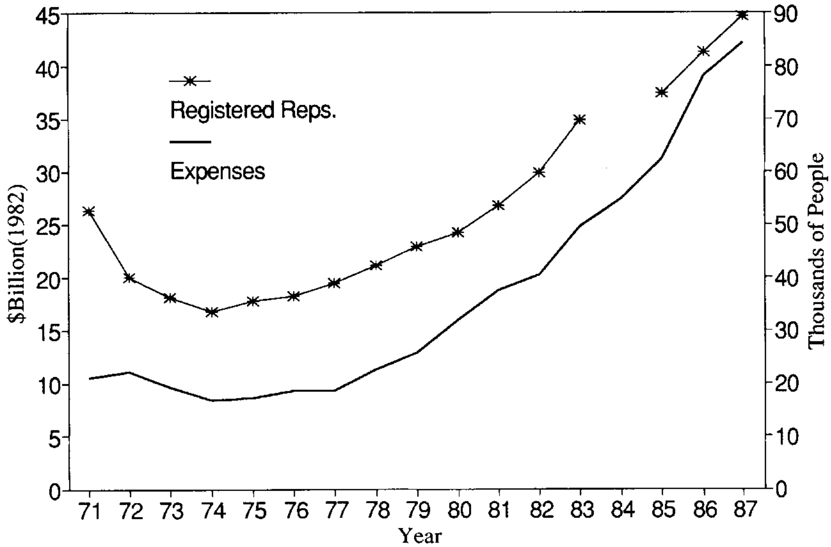

Fig. 5.2 Select inputs to NYSE member firms (real expenses, registered representatives)

produce intermediate outputs; trading services, knowledge and analysis to support trading decisions, and sales efforts.

What is the real output of the stock exchange? Has it grown as dramatically as figure 5.1 suggests? These are the issues addressed in this paper. Our inquiry focuses on several related analytical issues arising in the nature of the changes in stock exchange activity in recent years.

Baumol (1965) lists five ways in which the operations of securities markets produce a social output. For our purposes, we classify these into three administrative and two informational outputs. The administrative outputs are access to capital, liquidity, and low administration costs. The existence of securities markets permits any particular enterprise to be owned by many small capitalists, each diversified. This permits the sharing of risk. Further, the capitalists can have a shorter time horizon than the enterprise; the existence of a price at which the individual can sell shares means that the investment is liquid. The additional liquidity may reduce risk as well as lower investor costs. Finally, when compared with other forms of financial intermediation, the securities exchanges can involve considerably less administrative effort for the transfer of funds.

The informational outputs of the exchange are twofold. The importance of each output depends on the belief that securities prices reflect fundamentals, that is, the expected future earnings stream of the enterprise. First, information about the firm's prospects could be useful to investors in their effort to evaluate the wisdom of management's plans for the firm. For the single investor, whether individual or institution, that information is potentially useful in deciding whether (and at what level) to continue to invest in the firm. For a particular firm's investors taken as a group, it is useful in selecting, evaluating, and compensating managers. Second, because stock prices are informative, they offer guidance to business management—information on the current cost of capital which is so important in determining the level of investment which it is appropriate for the firm to undertake. Thus, the securities markets could usefully transfer information out of the firm to investors, or reflect information (presumably known by some investor) that management would not otherwise know.

The dramatic increase in trading volume on the stock exchanges might have represented an increased service along any or all of these five dimensions. The origins and form of the increase in trading suggest the importance of the two informational dimensions. The increase is happening worldwide—not just in the United States. In the United States, it is driven by very rapid technological change based on the use of telecommunications equipment and computers and by the 1975 deregulation of stock brokerage. The technological effects have been much the same outside the United States, but deregulation has played a much smaller role until recently.

The new technologies and deregulation have made trading cheaper. The technologies let individual traders in brokerage houses more closely monitor and react to events in and affecting the markets. Today, they have Quotron terminals and Unix workstations to follow many different sources of information and act on them. The deregulation and technology let investors outside brokerage houses trade more cheaply at the margin. The exchanges themselves have accommodated the traders' desire for rapid response with electronic market infrastructure. The NASDAQ small-order execution system and the NYSE direct order transmission system are examples that permit reasonably direct computerized trading. One effect of these lower costs is that more traders in more countries participate in globalized markets. This creates an opportunity to execute very large trades quickly and without much effect on price—increased liquidity in the short term.

These changes create opportunities for traders to get and use information about companies and about the market. When a trader can easily take and later liquidate a large position, there are opportunities to earn an expected profit on even a small information advantage. As a result, traders pursue ever smaller arbitrage opportunities, better analysis of public information, and (illegal as well as legal) private information.

One response to this increased liquidity is the systematic pursuit of arbitrage opportunities. Wall Street "quants" perform computer intensive research not unlike that of professors of finance. The quants' goals, however, are to find systematic departures from theory and then to trade on them. Increasing liquidity means that smaller and smaller systematic departures can be exploited. Competition among potential traders means that, over time, only smaller and smaller departures persist.

Similar opportunities exist on the fundamental side of securities research and trading. A trader who can anticipate the contents and implications of a public announcement about a company can usually make a profit. Increased liquidity and lowered transactions costs mean that it is increasingly valuable to expend resources on anticipation of public announcements. The analyst's research activity is the more valuable, the more correct it is and the more unique it is; something known to everyone is already reflected in the stock price. As a result, competition among research analysts and traders leads to the pursuit of *a priori* less and less promising fundamental analysis. The marginal fundamental research project always earns zero expected return on the costs of gathering and processing the information about the company. As with the quantitative/arbitrage research efforts, the competition among analysts and traders can take two forms. The analyst can attempt to get to a better answer than analysts at other trading houses. This typically takes either better-informed or smarter analysts; the former are expensive, the latter subject to rapidly diminishing returns. The other form of competition involves getting to the answer more rapidly and trading on it earlier. This form of competition is a very effective destroyer of rents. But it suggests a substantial increase in the speed with which information is impounded in security prices.

The nature of the changes in securities markets suggests two directions of increase in the real output of the exchange: The first is the direct effects of lowered trading costs on the administrative outputs of the exchanges. The second is the indirect effects of increased informativeness of the prices of securities. It appears unlikely that either effect represents a large increase in the real output of the securities exchanges. Almost all of our formal argument is concerned with the informativeness effects, but we will briefly review the administrative effects here.

Trading costs are not primarily costs of *owning* publicly traded companies or costs of the *existence* of publicly held companies. A buy-and-hold life-cycle investor, for example, gains only incrementally from the decline in trading costs over the last decade and a half. Thus enterprises can be owned by a broad range of well-diversified investors either before or after the trading cost decline. The administrative effects seem likely to be second order.[6]

The value of quicker incorporation of information in stock prices is a more

6. The increased liquidity of the exchanges does provide some benefits, such as opportunities to rebalance portfolios at lower cost. In an economy with identical stockholders, equilibrium portfolio balancing involves no trades. But in an economy with stockholders in diverse tax circumstances, the lowered trading costs may permit more effective use of the securities markets to engage in tax-lowering trades. These, depending on one's view of the tax code, either usefully broaden the base of capital taxation or destroy useful attempts to tax favor particular types of capital.

difficult question. We ultimately conclude that this, too, likely represents an unimportant improvement in the output of the stock exchanges. But to reach this conclusion we need a more careful treatment of the potential social gains to informative stock prices. If outside analysts research companies more, and if much of the information they discover is reflected in the price of the stock, who finds this information useful and how? We will provide models of both of the two information flows discussed above, that to investors and that to management.

The question of the value of information in stock prices is a difficult one in no small part because of the plausibility of the hypothesis that the stock market *should* have grown more informative over the last decade. Many firms in the United States, facing increased worldwide competition, have felt themselves to be in a more difficult environment. It is a cliché of the 1980s that firms need to refocus on decision making for the long term and on competitiveness. These are times in which it is quite plausible that improved mechanisms for aligning management and shareholder interests on the long run could be particularly valuable. It is also plausible that, in apparently unsettled times, the stock price could communicate more things to management that it does not know.[7]

In what follows, we provide separate but similar analyses of the two informational hypotheses: (1) more informative securities prices better align investor and management incentives; and (2) better information in securities prices inform management about investment prospects. In both cases, we assume that the stock grows more informative because of outsider traders. These are self-interested investors who gather information about companies and trade in their securities in the hopes of private gain.

We use a standard model of information gathering and trading in the stock market, that of Grossman and Stiglitz (1980). In their model, the incentive to gather information about companies arises because informed investors can trade on it. Because they do trade on the information, equilibrium price is correlated with the information; by this mechanism, the securities market can grow more informative. Rational expectations by other investors limit the size of their trading gains, however. Information that traders gather and trade on is reflected partially in stock prices, partially in expected profits to the informed trader. The more investors know something, or the larger position informed investors take, the more the information tends to be revealed by the stock price. In equilibrium, the number of traders who become informed is determined by the cost of gathering the information and the return. At a market equilibrium, so many traders become informed that they drive the return to information (suitably adjusted for risk) down to the cost. This model provides

7. Of course, it is also a cliché of this period that the stock market does none of these things, but rather the reverse, by focusing companies on short-run returns. This is a point to which we shall return.

us with a way to understand the part of the problem concerning information gathering by outsider traders.

There are a number of ways in which more rapid or more complete reflection of information about companies in stock prices could be a socially valuable output: (1) stock market prices are often used in compensation contracts for high company officials; better information might make this principal-agent problem go better; (2) the stock market serves to guide investment. Better information might guide it to better uses; and (3) takeovers, leveraged buy outs, and so on, might provide discipline in management that would be more effective with better public information. By building models of (1) and (2), we argue that any beneficial effects are likely be small. Our arguments will clearly not apply to takeovers.

Theories of corporate officers' compensation suggest that use of the stock price can align officers' and stockholders' interests. There may be substantial costs of waiting to compensate officers on the basis of how their decisions actually work out in the future. Instead, the argument goes, the forward-looking character of the stock price lets the compensation be done closer to the decision point. This leads to an interesting puzzle. Many managers appear to believe that compensating them with stock tends to focus them on the present, not the future. Rather than encouraging high-payoff investments in R&D or other long-lived assets, the stock market encourages managers to show immediate profits. Further, this tendency has been getting stronger over time. As the managers see it, the markets are systematically shortsighted. Their irrationality translates into an irrational compensation scheme.

The managers, it turns out, are very likely right about everything but the irrationality. In the next section, we present a simple model of managerial compensation, a model based on the price established in a fully rational stock market. In the compensation model, managers' and stockholders' goals are not necessarily identical. Shareholders care only about their return; managers care only about their compensation and the effort they expend to get it. The incentive contract offered the managers uses the stock price to compensate them. To the extent the stock price reflects the future value of the firm, this tends to make the gap between shareholder and manager interests smaller. Managerial attention might, for example, be directed either to R&D or to making the quarterly earnings report look right. The first activity is high payoff, difficult to evaluate, and uncertain; the second is the reverse. A good incentive contract rewards the first and ignore the second. Our model determines whether the self-interested information-gathering and trading behavior of stock-market participants, who might gather information about either managerial activity and trade on it, leads to such a contract.

For the purpose of compensating the managers, shareholders would like the stock price to reflect the R&D management activity more, the earnings report less. But investor research may have the reverse effect. The stock market equilibrium does not systematically tend to invest in information about the more valuable activity. Although we show this result precisely below, it is easy to anticipate its intuition here. From the point of view of the compensation contract, one would like the stock price to reflect managers' *value added*. But that is not what traders care about; they want to know about the *value* of the firm. In both gathering information and trading on it, their incentives lead them to the wrong activity.

Our analysis of the way the stock market guides investment is similar. The role of information is different here. There is information about the firms' prospects not known to the firms' officers or directors. The market, by displaying a large q (Tobin 1969; Hayashi 1982), can signal the need for an expansion of the firms' capital stock.

Our analysis of this situation closely parallels the previous one. Once again, we distinguish between two different pieces of information to gather and trade on. One of these concerns the value of the firms' existing projects; the other, the value of the incremental investment project. To guide investment correctly, the market would have to emphasize the latter information. Once again, the reverse is true; for the case of a small incremental project, stochastically independent of existing projects, the stock price reflects *only* the value of existing projects.

Once again, the intuition is clear. Traders care about the value of the firm, which may be determined overwhelmingly by existing projects. They are not necessarily interested in the value added of the incremental project.

5.1 Real-Side Decisions, Managerial Agency, and the Long-Run Value of the Firm

The first value-of-information issue can be addressed in a basic principal-agent model of relationships between the owners of a firm and its stockholders. The classic approach to this problem combined three elements.[8] First, managers' and shareholders' incentives are not aligned a priori; managerial effort needs to be elicited by incentives under moral hazard. Second, the board of directors is sophisticated in setting the managerial compensation scheme but is limited in what it can observe; compensation is based on observable indicators of the *effects* of managers' actions, not on the actions themselves. Although the board cannot observe the manages' actions, it correctly anticipates the effect of incentives on managerial actions. Our model also has rational expectations in another sense. The stock price is equal to the present value of per-share earnings, adjusted for risk and deducting any managerial compensation. This equation is not an identity that managers take as given. Rather, it is an equilibrium condition.

8. Cf. Wilson (1969), Spence and Zeckhauser (1971), and Ross (1973). Our modeling details follow Holmstrom (1979).

The value of stock market information for managerial compensation can be addressed in this framework with two simple changes. First, we give the stock market itself an explicit informational role. We follow Grossman and Stiglitz (1980), Hellwig (1980), and Admati and Pfleiderer (1987) by introducing outside traders who can research the firm and trade on the results of their research. We use the standard model in which outside traders' information is partially revealed by the stock price. If it were fully revealed, there would be no incentive for research. To capture the long-run/short-run distinction of our introduction, we also model the outsiders as capable of researching any of several different aspects of the firm. This also leads immediately to our other novel feature. We let managers choose a vector of activities, not a single effort level. Thus, the model has a rich enough logical structure to permit statements like "outsiders research short-run earnings, not long-run prospects, so managers direct their efforts to the short run."

We make specific assumptions about functional forms and distributions, following the literature. In particular, both shareholders and managers have constant absolute risk aversion preferences about wealth, and managers' utility is separable in wealth and effort. The joint distribution of the future value of the firm and all signals observed by outside traders is normal.

Ultimately, the firm will have earnings

$$V = f(\mathbf{x}) + \Sigma_i \Theta_i, \tag{1}$$

where $\mathbf{x}$ is a vector of choice variables for management, and Θ is a random term outside anyone's control. These revenues are discounted to the present. For our application, it is natural to think of $f(\mathbf{x}) + \Theta$ as being calculated from the sum of present earnings, y_1, and the present value of future earnings, y_2. Both y_1 and y_2 depend on $\mathbf{x}$, perhaps differently, and the sum of their random components is Θ. The manager/agent picks $\mathbf{x}$, and bears some private effort costs, $c(\mathbf{x})$, in doing so. So far, we closely follow the usual agent-theoretical models of managerial compensation, except that $\mathbf{x}$ is a vector. The problem for the directors/shareholders, then, is be slightly more complex than usual. They need to elicit not only overall managerial effort, but the *right mix* of the different efforts, $\mathbf{x}$.[9]

We follow the literature by assuming that compensation cannot be based on $\mathbf{x}$, which is fundamentally unobservable, or on V, which is observed too late. Instead, compensation is based on the current stock price, P. The intuition held by both economists and practitioners has been that P reflects all publicly available information about V. Thus, under a fundamentals or efficient-markets theory of how P is set, management's incentives are aligned with shareholders.

9. The effort variables, $\mathbf{x}$, are naturally unitless, and we have written both $f(\mathbf{x})$ and $c(\mathbf{x})$ as arbitrary functions. Clearly, there is an arbitrary normalization here. We could write $f(\mathbf{x}^*) = \Sigma_i x_i^*, c(x_i^*)$, without any loss of generality.

The net compensation of the manager is given by:

$$T(P) - c(\mathbf{x}), \tag{2}$$

where $T(P)$ is a transfer or compensation function. We assume T is linear, $T(P) = t_0 + t_1 P$.[10] In this framework, **x** is subject to moral hazard. A self-interested manager will set x_i to maximize expected monetary income minus effort costs, adjusted for risk. In certainty-equivalent terms, this is

$$U_m = \max_{\mathbf{x}} t_0 + t_1 E[P \mid \mathbf{x}] - c(\mathbf{x}) - \frac{a}{2} t_1^2 \sigma_p^2. \tag{3}$$

The last term is the risk premium in the manager's compensation. Because higher **x** generally leads to a higher mean price, (3) does represent an incentive contract. As long as the managers' coefficient of absolute risk aversion, a, is positive, the solution $t_1 = 1$ and $t_0 = -E[V]$ is not optimal, because it requires the managers to bear too much risk.

We assume that directors, in setting $T(P)$, act in the long-run interests of all shareholders.[11] They will pick the function $T(.)$ to maximize the appropriately risk-adjusted terminal value of the firm. We will return to the details of this problem.

In the standard model with exogenous information, **x** is set by the managers according to (3). The stock price is set by

$$P = E[V \mid \mathbf{x}] - T(P) - \text{(shareholders' risk premium)}, \tag{4}$$

because constant shareholder risk aversion implies linearity in $E[V]$ and rational expectations implies the value of the firm is calculated at the managers' equilibrium action. Finally, t_0 and t_1 are set by the board to maximize shareholder welfare subject to (3). Except in some special cases (certainty, risk-neutral manager), the equilibrium does not attain the first best. Perhaps better information from an active set of researcher/investors would help.

5.2 Investor Preferences and Stock-Market Equilibrium

We let the informativeness of P about V be endogenous. Individual or institutional investors can research different aspects of V and then trade on that information. We assume that in performing these activities, investors are self-interested. They trade on their research information only to the extent it gives them a risk-adjusted return. They only do research that leads to profitable trades. We will follow Grossman and Stiglitz (1980) in modeling one effect of

10. This can be justified as corresponding to an optimal choice when the model is regarded as the reduced form of a more detailed, dynamic formulation. See Holmstrom and Milgrom (1987).

11. There are no investment bankers or raiders on boards *forcing* shortsightedness in our model.

this activity. The more informed investors trade, the more P reflects their research efforts. If other investors have rational expectations, they use the information in P. This limits the private value of research. In our treatment, the increased informativeness of P has a *second* spillout; the board of directors can use it in a compensation contract.

The research possibilities are about different aspects of V. We assume that investors are grouped in types, i, each of which can research a particular aspect.[12] For clarity, we link each research aspect to a particular managerial effort level, x_i. In particular, we assume an informed investor of type i observes,

$$y_i = x_i + \Theta_i. \tag{5}$$

This is an *imperfect* signal of the effort x_i because it contains noise. It is also an *incomplete* signal of the ultimate value of the firm. Because

$$V = f(\mathbf{x}) + \Sigma_i \Theta_i, \tag{6}$$

any particular research project bears on only a particular aspect, such as the current or future earnings of the firm. Our assumption that there are multiple nontrivial signals and that any particular investor sees at most one of these means that each informed investor is still somewhat uncertain about V. Thus no risk-averse investor takes infinitely large positions in the security. We will investigate two different problems: a short-run problem in which the amount of research being done is fixed and a long-run problem in which research is endogenous.

We assume that investors are risk averse and that they have constant absolute risk aversion. An investor's utility function over *ex post* wealth is $U(W) = -\exp(-aW)$ where a is the coefficient of (absolute) risk aversion. This specific form of preferences is helpful because it, together with competitive rational expectations and normally distributed errors, implies a linear asset-demand equation. An investor who observes signal y_i demands stock according to

$$q_i = \frac{E[V \mid y_i, P] - P - T(P)}{a \operatorname{var}(V \mid y_i, P)}. \tag{7}$$

The numerator in (7) is the investor's expected return on a share of stock. A positive signal leads informed investors to take a long position, a negative signal to short. The denominator is risk aversion times the variance of the

12. This is an assumption of convenience. Models in which investors choose research projects, possibly pursuing several, have been investigated by Admati and Pfleiderer (1987). These models quickly become extremely technically complex. Price-taking investors who research multiple projects would add little to our treatment. Takeover investors who investigate everything and mount a raid are a different matter.

investor's risky return. Investors with better research (i.e., smaller variances around ultimate value) take larger positions.[13]

Why are both numerator and denominator in (7) written as depending on P as well? In rational-expectations equilibrium, P reveals some of the information about y_i. Suppose that the results of one particular kind of analysis, for example, y_i, suggests low future stock value. Researcher/investors who see y_1 dump the stock, *and its price will therefore be lower.* As a result, P incorporates some of the information in the y_i. This dependence could be exploited by an uninformed investor who demands

$$(8) \qquad q_u = \frac{E[V \mid P] - T(P)}{a \operatorname{var}(V \mid P)}.$$

The dependence between the price of the stock and researchers' information is also the reason the board can use P as an input in managerial compensation, as we shall see.

To investigate the informativeness of the stock price as a signal of the research's contents, we now examine the equilibrium price equation. Each informed investor of type i behaves according to (7); let there be λ_i such investors. (For the moment, we assume λ is exogenous.) Similarly, let there be λ_u uninformed investors, and let the demand by noise traders be z. Normalize by $1 - \lambda_u = \Sigma_i \lambda_i$. Then price solves the zero net supply equation:

$$(9) \qquad 0 = \lambda_u q_u(P) + \Sigma_i\, \lambda_i q_i(P, y_i) + z.$$

Because (9) is linear, P is a linear function of the y_i and z, and thus normal. The variance of P and its covariance with the y_i are determined by (7) − (9).

This relationship is simple to understand if we write out (7) and (8) explicitly. Let β^v_{pi} be the coefficient of P when V is regressed on P and y_i, and let β^v_{ip} be the coefficient of y_i. Write the manager's compensation $T(P)$ as $t_0 + t_1 P$. Then,

$$(10) \qquad q_i = \frac{E[V] + \beta^k_{pi} P + \beta^k_{ip} y_i - P - t_0 - t_1 P}{a\, \sigma^2(V \mid y_i, P)}.$$

Because an informed investor of type i can observe both y_i and P, she can condition on both. Both are valuable information; P contains information about other traders' information. The relation between signal y_i and trading behavior depends on two things; β^v_{ip}, which measures $\delta E[V \mid \cdot]/\delta y_i$, and $\sigma^2(V \mid \cdot)$, which measures the risk borne by a type-i trader.

Similarly,

13. Following Grossman and Stiglitz (1980), we write the problem as if the stock of the firm at hand were the only risky asset in the economy. Admati and Pfleiderer (1987) treat the case of an investor demanding a portfolio of different securities. Although the definition of the riskiness of a further investment in a particular firm is changed by the portfolio treatment, the fundamental parts do not seem to be altered.

(11) $$q_u = \frac{E[V] + \beta^v_p P - P - t_0 - t_1 P}{a\,\sigma^2(V \mid P)},$$

where β^v_p is the coefficient of P in a regression for V with no other regressors. Uninformed traders can condition only on the information revealed in P. They are always at greater risk than informed traders, because $\sigma^2(V \mid P)$ is necessarily larger than $\sigma^2(V \mid y_i, P)$.

The distribution of P in equilibrium is then determined by

(12) $$P = (\text{constants}) + \left\{\sum\nolimits_i \frac{\lambda_i \beta^v_{ip}\, y_i}{a\,\sigma^2(V \mid y_i, P)} + z\right\}\frac{1}{\Delta},$$

where

(13) $$\Delta = \sum\nolimits_i \frac{\lambda_i\,(\beta^v_{pi} - t_1 - 1)}{a\sigma^2\,(V \mid y_i, P)} + \frac{\lambda_u(\beta^v_p - t_1 - 1)}{a\,\sigma^2\,(V \mid P)}.$$

5.3 The Alignment of Shareholder and Manager Interest

Knowing that research and investment leads to $\text{cov}(y_i,P) > 0$, and wanting to reward x_i, a value-maximizing board of directors will set managerial compensation to depend on P. They anticipate that managers will supply effort in order to earn stock-price-based income. The board's problem is to maximize shareholder well-being subject to (3) and subject to $U_m \geq U_0$, the manager's opportunity salary.

This problem takes the form

(14) $$\max_{t0,\,t1,\,\mathbf{x}} \lambda_u V_u + \sum\nolimits_i \lambda_i V_i \quad \text{s.t. (3)} \quad U_m \geq U_0.$$

That completes our statement of the model.

The ingredients of the model, then, are threefold. Managers are self-interested and need an incentive contract to align their interests with shareholders. The function $f(\mathbf{x}) - c(\mathbf{x})$ need not be symmetric, so some activities can be more valuable than others. The management incentive contract should focus attention on those activities. The second ingredient is that investors are self-interested. They research those activities of the firm on which they can hope to make profits as informed outsider traders in informationally efficient markets. The third ingredient is the board, which maximizes shareholder welfare.

5.4 Exogenous Number of Informed Traders

The problem *would* become easier if the stock price came to incorporate more information about the more important managerial efforts, x_i. In (12), we see that P is a linear function of the y_i, with coefficients depending on the number of informed traders of type i, λ_i, and on the equilibrium behavior of informed and uninformed traders. The coefficient of y_i in the price equation (12) is proportional to its coefficient in type-i investors' stock demand equation (10). Thus, we see that the stock price coefficient of y_i depends on the number of type-i investors and on the strengths of their tendency to trade on useful information. The board's problem is made easier if investors have a systematic tendency to (1) become informed about or (2) trade on information about the high-value managerial activities.

We divide our discussion of the results of the model into two parts for convenience: The first part takes λ as exogenous, though informed investors' trading behavior is endogenous. Thus, the results in this part answer the question, Does informed investors' trading behavior make the stock price a better instrument for the board's managerial compensation problem? This is not such an unlikely prospect, because the informed trader of type i observes a signal correlated with managerial activity x_i.

We now show that informed investors' trading behavior has no particular tendency to favor managerial activities for which $f'_i(x_i) - c'_i(\vec{x})$ is large. To make the results simple to state, we first treat a special case and then the more general problem. In the special case, the information structure of the problem is symmetric in that there are an equal number of informed traders of each type and in that each Θ_i has the same variance and all pairs of Θ's have the same covariance.

PROPOSITION 1 *(symmetric information structure, exogenous λ). Suppose all of the λ_i are the same, and that $cov(\Theta_1, \ldots, \Theta_n) = cov(\Theta_{i1}, \ldots, \Theta_{in})$ for any permutation of the activities. Then the behavior of informed traders rewards management for all activities equally, regardless of their relative value.*

Proof. Equations (5), (10), (11), and (12) determine the joint distribution of P, Y, V, and Z. Under symmetry, $\beta^v_{pi} = \beta^v_{pj}$ and $\sigma^2(V \mid y_i, P) = \sigma^2(V \mid y_j, P)$ for any pair of i, j in any solution. The manager's marginal incentive to perform activity i is

$$1 + \frac{1}{\Delta}\frac{\lambda_i \beta^v_{ip}}{a\,\sigma^2(V \mid y_i, P)}; \tag{15}$$

this is set equal to $\delta c_i(\vec{x})/\delta x_i$ by the manager. The second term in (15) is the contribution of informed trading to the managers' marginal incentive. Under symmetry, it is the same for all i.

A more general result follows the same logic.

PROPOSITION 2 *(arbitrary information structure, exogenous λ). Equilibrium outsider trading does not lead a stock-price-based compensation contract to differentially reward high-value activities (those with $\delta f/\delta x_i - \delta c/\delta x_i$ high) or those where managerial effort is elastic. Instead, the equilibrium marginal* *incentive for managers to perform activity* x_i *versus activity* x_j *is entirely determined by* λ *and the joint distribution of* Θ.

Proof. The joint distribution of *P, Y, V,* and *Z,* now possibly assymmetric, is determined by the same equations as in proposition 1. Thus, the relative size of β^v_{ip} versus β^v_{jp} and $\sigma^2(V \mid y_j, P)$ versus $\sigma^2(V \mid y_i, P)$ is entirely determined by the joint distribution of Θ, *V,* and *Z,* and by λ. It does *not* depend on $f'_i(x_i)$ versus $f'_j(x_j)$ or $\delta c(\vec{x})/\delta x_i$ versus $\delta c(\vec{x})/\delta x_j$.

An even sharper contrast can be seen by comparing the incentives determined by the stock market versus the optimal incentives that the board would desire. Holmstrom and Milgrom (1990) consider the problem of multitask performance incentives. They show (under weak restrictions) that the optimal incentive scheme rewards the activities at the margin according to

$$(16) \qquad (I + \frac{a}{2}\,\mathrm{cov}(\Theta)\,[\delta^2 c/\delta x_i\,\delta x_j])^{-1}\,[\delta f/\delta x_i],$$

where [ ] is used to indicate the vector or matrix whose typical element is inside the brackets. The stark differences are immediate. The optimal incentive depends (of course!) on f'_i. The equilibrium stock-price-based compensation scheme does not. Keeping the level of $\vec{x}$) fixed at the equilibrium point, the slopes f_i can be changed arbitrarily and the stock market's behavior is unchanged. In particular, we can make an activity such as massaging the earnings report arbitrarily worthless, f'_i near zero, and the stock market will continue to emphasize it. The optimal incentive depends on the supply elasticities of effort $(\delta^2 c/\delta x_i \delta x_j)$, and these are lacking in the stock-market equilibrium as well. Only the distribution of Θ is common to the two problems, and it plays very different roles. In (12), we see that traders particularly emphasize the high-variance Θ's. In the optimal contract, high-variance signals are emphasized less.

Why do these results hold? The intuition is simple. Our investors trade on information to the extent that it gives them a capital gain. In equilibrium, this comes at the expense of uninformed traders, traders who observe a different signal, or noise traders. To make a capital gain, a trader wants to know about the future value of the firm, $f(\vec{x})$, not managerial value added, f_i. The private value of information for trading is entirely determined by who knows it, or who knows variables correlated with it. It is unrelated to the value of the information in compensation of managers.

In a related paper (Paul 1990), one of us takes up the general question of the equilibrium information content of *P.* With a general joint distribution for Θ and *V,* on which signals do investors tend to trade most heavily? For an important class of distributions of Θ and *V,* equilibrium informed outsider trading systematically weights the *noisiest* signals the most heavily. (See propositions 2 and 3 in Paul 1990). As Paul (1990) points out, this is exactly the reverse order from what the board would like in the case where $f(\vec{x}) - C(\vec{x})$ is maximized at $x_i = x_j$. Instead of putting weight, as the optimal linear compensation package would, on the least noisily signaled effort, in Paul's results the investors do the reverse.

At this juncture it should be clear that there is no systematic tendency for trading by those investors holding that information the board would like to see reflected in the price. If anything, rather the reverse seems to be true. Outsider trading is guided by the logic of the stock market itself, not by the relationship between the stock market and the firm's decision problem.

5.5 Investor Research Decisions

Yet propositions 1 and 2 refer to an environment in which investors' *research* is exogenous. The informativeness of P is endogenous, but the *information available* to be reflected in P is not. Investors cannot pursue research opportunities focused on particularly valuable x_i. Would a model with endogenous research effort have more favorable implications for the role of stock-market compensation in management decision making?

The simple answer is no. And the simple reason follows directly from the Grossman-Stiglitz equilibrium condition for endogenous research. Grossman and Stiglitz (1980) assume that traders invest in becoming informed in signal i until their utility gain from trading on y_i is just equal to the cost of the signal. The cost of effort to the manager and the value to the firm appear nowhere in this calculation.

Let the research costs of aspect i be R_i. Let the certainty equivalent of the return to knowing Θ_i be V_i. Let the certainty-equivalent return of an uninformed investor be V_u. Then λ_i, the mass of informed investors of type i, rises until

$$V_i = V_u + R_i. \tag{17}$$

From Admati and Pfleiderer (1987), proposition 3.2, we know that $V_i - V_u$ is equal to

$$\frac{1}{2a} \log \left[\frac{\sigma^2 (v \mid P)}{\sigma^2 (V \mid y_i, P)} \right]. \tag{18}$$

It is immediate from (18) and (12) that the return to purchasing signal i for the marginal investor is proportional to the tendency of type-i investors to trade on their information, other things equal. (The other things here include β^v_{ip}, so this may be overstrong. Yet β^v_{ip} and $\sigma^2(V \mid y_i, P)$ should move in opposite directions in the cross section of signals.) In particular, the return to the marginal investor is exactly proportional to the strength of a trader's response to a given forecast. (See Admati and Pfleiderer 1987, equation 3.4.) It therefore should not be surprising that the marginal investor's behavior will not be particularly directed toward the high-value investments.

The following result is immediate by symmetry:

PROPOSITION 3 *Under the symmetry conditions of proposition 1, and assuming* $R_i = R_j$, *the mass if informed investors of each type,* λ_i, *is the same for all* i. *Thus, there is no tendency for endogenous information to favor the high-value research activities.*

There seems little room left; the use of a stock-price-based compensation contract does not solve a multiple-decision moral-hazard problem. Although it may possibly be good at eliciting overall effort from managers, it has very little role in focusing managers on those particular activities that create shareholder wealth over the long run. This result may help explain the CEO-compensation puzzle. Jensen and Murphy (1989) try to measure the empirical relationship between CEO compensation and growth in shareholder wealth. They find a weak relationship, suggesting CEOs are *not* compensated primarily according to *P.* Why might this be? Suppose the long career path to becoming a CEO weeds out all candidates who disvalue overall effort, leaving only the driven. Then our results show that there is no value to using the stock market in focusing the CEOs efforts; other mechanisms must be employed for that.

5.6 The Value of Externally Generated Information in Managerial Decision Making

In the second theory of valuable information in the stock price, it is the firm's managers and board who learn from it. Part of this theory is similar to that of the last section. Outsider traders research the firm and discover profitable new opportunities. To the extent that they trade on this research, they bid up the price of its shares. Yet part of this theory is different as well; in it, the firms' managers do not know about the profitable opportunities but instead learn about them from observing the share price.

This story is usually told in a slightly different way, in which it is the *firm's cost of capital* that is signaled to the managers and the board through its share price. Suppose outsider traders, basing their decisions on private research about fundamentals, drive up the share price. The resulting low cost of capital (rightly) means the firm should acquire additional capital and expand. Baumol (1965) points out that the informational story does not critically turn on the true marginal opportunity cost of capital to the firm. The new project could be financed out of retained earnings, so that there is no relation between the share price and marginal opportunity cost of capital. This does not affect the argument that the stock price might signal valuable opportunities to the managers and board. Indeed, the main point here is not about investment of new capital at all, but instead about the use of the stock price *by insiders* to gain useful information about the firm's prospects.

A similar role for the stock price is central to *q*-theory models of investment (Tobin 1969; Hayashi 1982). It is easy to see, however, that there is no relationship between the validity of the *q*-theory investment model and the validity of the valuable-information theory. In the q model, the origin of the information about new projects is unimportant.[14] Management can research the profitable new opportunities and tell analysts about them. Alternatively, people outside the company can have done the research, and management can have inferred the opportunity from the high stock price. In either event, $q > 1$ and the firm should expand. The usefulness of q-theoretical models in econometric studies of investment, therefore, has nothing to do with the direction of information flow.

The value of increased stock-price informativeness, however, does turn critically on the direction of information flow. There is little informational value for managers in having the stock price quickly reflect things they have just told analysts. If outside analysts learn something about new projects that managers do not know and trade on it to the point it is reflected in the share price, then there is an informational gain. Managers, seeing opportunities reflected in the share price, can move to fund the projects.[15]

This section has a very simple model of this potential information flow. The model suggests that the flow cannot be very important. The key assumption of the model is that the stock price reflects two kinds of outsider trading and research. The outsiders can research and trade on information about the firm's incremental projects. But they can also research and trade on information about the firms' *existing* projects. Securities prices confuse these two effects and thus provide a poor signal of the value of the incremental projects.

We can reuse much of the notation and many of the ideas of the previous section. We continue to assume that the ultimate value of the firm is determined as

$$V = f(\vec{\mathbf{x}}) + \Theta = \Sigma_i f_i(x_i) + \Theta_i, \tag{1}$$

where $\vec{\mathbf{x}}$ is a vector of choice variables for management, and Θ is a random term outside anyone's control. But for our purposes in this section, the interpretation of the variables changes somewhat. First, management and the board together pick $\vec{\mathbf{x}}$, and we assume here that they have no agency conflicts. All $\vec{\mathbf{x}}$ are already decided except x_n, the new project. Further, we think of x_n as a single go/no-go decision; undertake the project or not.

The information structure is as follows: Management knows all of the $f_i(x_i)$ except $f_n(x_n)$. The value of the incremental project, $f_n(x_n) + \Theta_n - c$, is a normal random variable. Management knows none of the Θ_i, nor can they be

14. Indeed, Hayashi's formal model (1982) has no private information at all. All investors are equally informed, and the stock price reflects fundamentals. This is all that is needed for a q-theory model.

15. As far as we can detect, few managers claim to be the recipients of such signals, and few investors the senders. Yet they would not; managers do not lightly admit that outsiders know anything useful about their companies, and successful outsider traders earn more if they keep their own counsel. The exception is investors who have taken large positions in firms and who use takeover threats, seats on the board, and other large-scale mechanisms to compel policy changes. We shall return to this point.

learned by management. Outside traders can research any or all of the $Y_i = f_i(x_i) + \Theta_i$, including $Y_n = f_n(x_n) + \Theta_n$.

What management and the board would like to learn is the expected value of the new project, $f_n(x_n) - c$. If they could directly research the signal Y_n, they would have a noisy (because of Θ_n) signal of this. It is clearly (privately) cheaper to let the outsider traders do the research and to use the stock price as a signal. To investigate the information management can glean from this strategy, we investigate the distribution of the price of the firm's stock under the assumption that the incremental project is going to go forward.[16]

The trading, research, and other activities of outsider traders go forward exactly as in section 5.1, above. In particular, the equilibrium distribution of the stock price is determined by (12):

$$P = (\text{constants}) + \left[\sum_i \frac{\lambda_i \beta_{ip}^{v} y_i}{a\, \sigma^2(V \mid y_i, P)} + z\right] \frac{1}{\Delta}, \tag{12}$$

The implications of this are immediate and straightforward. The stock price, as a signal for Y_n, is noisy, potentially very noisy. Consider, for example, the case in which there are nine existing projects and the distribution of the Y's and V is symmetric in the sense of proposition 1, and that all the Y's are independent. Then P is an equally weighted average of ten signals, only one of which is of interest (and also a function of the pure noise z). There is once again no necessary relationship between the pattern of information collection that would support the real-side decision making of the firm and the pattern that self-interested outsider traders would consider. The real-side decision needs information about the marginal project; outsider traders care about the totality of the firms' projects.

Of course, if the signals Y_i are all highly correlated, the stock price will be a good signal for Y_n. In this case, the distribution of the marginal project and all the inframarginal projects are much the same, and P is highly correlated with the signal. Yet there is something very odd about this example, in which the managers do not know the value of the incremental project despite its high correlation with the inframarginal projects.

For a firm that is growing rapidly, the value of the incremental project can dominate in overall firm valuation. Then the financial markets may well guide investment. A variety of financial institutions reflect this. Venture capitalists certainly decide much about the allocation of capital to young firms. For somewhat older firms, the initial public offering process can involve an information flow to managers from investment bankers and institutional investors. Yet it is difficult to see how the same information flow could be important for

16. We assume, for purposes of the discussion, that there are no tricky gaming issues between management and the outsider traders. Suppose, for example, that management will withdraw the project if the stock-market reaction is adequately adverse. Then the value of the security reflects this prospect, and (12) does not hold. Considerations such as this can only complicate management's inference problem.

a mature firm or how capitalizing information into the stock price in minutes instead of days can add much value.[17]

We can state the general point easily in Hayashi's language (1982). The board and the managers would like to know marginal q, the incremental value to the firm of doing the additional project. Outsider traders' profits depend on average q, not marginal q. Thus the signal-to-noise ratio in P can be arbitrarily small, as in the case of an incremental project that is one nth of the firm and distributed independently of the inframarginal projects.

5.7 Conclusion

How rapidly has the real output of stock exchanges grown? Is it anything like as rapid as figure 5.1 suggests? Are the rapidly growing costs of having stock exchanges (fig. 5.2) merely the flow of resources into a sector making a booming social contribution? On balance, our analysis is not encouraging to a positive view on these issues. The gaps between social and private incentives to trade seem likely to be important in the modern era.

Neither of the two informational theories of the real output of the stock exchange suggests a large value for the increased activity of outsider traders. In both cases, the information that is valuable for making a real decision—compensating managers or deciding on a new project—bears no relation to the information impounded in prices by the activities of traders. The appropriate real decisions depend on value added—the value of the managers' decisions or of the new projects. The research and trading decisions of outsider traders are focused on the value of the firm, not on value added.

One of the best ways to become a cliché is to be a truth. Researching a firm's quarterly earnings report in the days after the end of the quarter but before the report is released may well be an excellent way to make a capital gain. At the same time, it could have no value in guiding management and could advance the date at which the board has a reasonable assessment of management performance by only a few days. Increased liquidity increases the resources devoted to this sort of rent seeking, without improving any real investment decisions.

Our analysis has not addressed takeovers, mergers, or the market for corporate control more generally. Traders in our analysis seek trading profits, not changes in control of the company. It is clear that a large trader seeking new management, a seat on the board, or other changes in the governance of the enterprise links real decisions and financial markets in a very direct way.[18] It is an interesting and difficult question whether recent trends on the stock ex-

17. We have also ignored any potential value of information about the firm to third parties, such as the owners or managers of other firms.

18. See Shleifer and Vishny (1986, 1989). They model the role a low stock price might have in attracting takeovers, and the managers' resulting desire to pick projects the stock-market "likes."

changes help or hinder this process. On the one hand, increased liquidity permits outsiders with valuable changes in corporate governance in mind to move more quickly. Yet such actors are typically held back by regulatory restrictions, which do not bind the arbitrageurs whose free riding is also enhanced by liquidity.

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