ON THE DESIRABILITY OF INSIDER TRADING REGULATIONS IN FINANCIAL MARKETS

by

Kjell Henry Knivsflå

A dissertation submitted for the degree of dr.oecon.

Norwegian School of Economics and Business Administration
Helleveien 30, N-5035 Bergen, Norway

ACKNOWLEDGEMENTS

First of all, I want to express my gratitude to my advisor Professor Frøystein Gjesdal for his patience with my many drafts, always giving insightful comments and suggestions.

Thanks also to the other members of my dissertation committee, Professor Steinar Ekern, Professor Richard R. Lindsey, and Professor Lars T. Nielsen for their helpful comments.

Finally, I want to thank the Norwegian School of Economics and Business Administration for support and scholarship.

All remaining errors are mine.

Bergen, January 4th, 1993

Kjell Henry Knivsflå

CONTENTS

PART II
BASIC MODEL AND ITS PROPERTIES

PART IV
OTHER EXTENSIONS

PART V
CONCLUSIONS

PART I

INTRODUCTION

CHAPTER 1

ON THE DESIRABILITY OF INSIDER TRADING REGULATIONS IN FINANCIAL MARKETS: A REVIEW ESSAY

First draft: June 1992,

Current version: January 1993.

ABSTRACT

The debate whether insider trading should be prohibited or not is the topic of this dissertation. This chapter offers a short review of the arguments for and against regulation, surveys the empirical literature, and discusses briefly the regulation on some major stock exchanges. Finally, an overview of the subsequent chapters is given.

1.1 INTRODUCTION

This dissertation analyzes, from an economic point of view, the desirability of insider trading regulations in financial markets. Its objective is to contribute to a better understanding of how financial markets work when insider trading is allowed, relative to the case where the supply of corporate insiders is limited by a law prohibiting insiders from trading on inside information. A better understanding could, for instance, be useful to stock market regulators by improving the design and enforcement of the regulations, and thereby improve the welfare of groups of individuals such as small, uninformed investors.

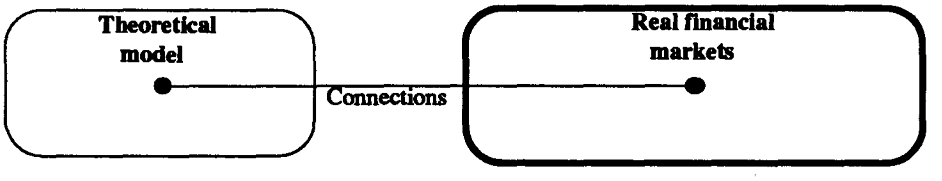
Insider trading is interpreted as being the security trades of corporate employees (and their tippees) based on material non-public information obtained at work or in connection with work. Information is considered to be non-public if it has not been disseminated in a manner making it available to investors in general. This interpretation of insider trading is narrow in the sense that not all informed trading is considered to be insider trading, and not all trades by employees need to be based on superior information. Non-public information obtained by employees at work or in connection with their employment is referred to as inside information. Individuals trading on such information are called corporate insiders or just insiders. Individuals trading on other information or for other reasons are called outsiders. They are often subclassified according to their trading motives as liquidity traders, hedgers, market professionals, market makers, broker - arbitrageurs, etc. Corporate employees may trade as outsiders if they trade for other reasons than motivated by inside information, for instance, because of liquidity needs or pure hedging. Finally, if the regulators so decide, insider trading may be allowed or prohibited.

The rest of the chapter is structured as follows. Section two discusses the research methodology used to analyze insider trading, sections three, four, and five review the arguments for and against a ban on insider trading, section six looks at empirical studies related to insider trading, section seven discusses the regulation of insider trading on major stock exchanges, section eight gives a short overview of the following chapters, and section nine concludes.

1.2 RESEARCH METHODOLOGY

Insider trading is analyzed by developing theoretical models with many of the properties characterizing real financial markets. The theory is therefore expected to shed light on effects caused by insider trading and its regulation. Figure 1.1 illustrates the research approach by distinguishing it from pure empirical research.

FIGURE 1.1 Theory vs reality



Although the model is supposed to reflect reality, effects found in the model are not necessarily present or important in real financial markets. A complete analysis of insider trading implies that the hypotheses deduced from the theory should be studied empirically to check whether the effects which seem important also are important in real world markets.

Despite, a theoretical model without a thorough empirical analysis is of interest in itself to gain better understanding about the potential effects caused by insider trading regulations. It could, for instance, help us in defining the range of behavior which we consider to be damaging, in identifying who the victims really are, and in being aware of possible allocational and distributive consequences which might be the price to pay for a prohibition of insider trading.

Financial market models with asymmetric information

Models for analyzing insider trading and its regulation are found in the extensive literature on securities markets with heterogenous information, especially the area called the "microstructure of financial markets." Admati (1989, 1991), Grossman (1989, chapter 1), and Kyle (1989) give excellent reviews.

However, the more specific theoretical foundation is found in Kyle (1984, 1985), and the extensive literature which uses Kyle's work as a basis for extensions and applications; see Admati (1991), pages 355 - 356. Glosten and Milgrom (1985) and Grinblatt and Ross (1985) have developed similar models which also take into account strategic behavior among superiorly informed traders (see also Laffont and Maskin (1990)). This dissertation builds on this foundation.

In the one period model of Kyle (1985), there is a single informed trader who observes perfect information about the future value of the firm. He trades, together with uninformed liquidity traders, by submitting orders to the market makers. If necessary, they clear the batch on their own account, and set the price at which the transactions are executed. The price is set by the support of information obtained from the net order flow, but the market makers cannot distinguish the informed from the uninformed. The market makers expect to earn zero expected profit because of the assumed competitive environment in the dealership market. On the other hand, the informed trader is risk neutral, and acts strategically by restricting his trade. This implies that the informed trader manipulates the information content of the transaction price to his advantage, and, accordingly, expects to earn an abnormal return at the expense of the liquidity traders. But the transaction price reveals some of the insider's information because his trading makes the net order flow correlated with his information. This revelation makes the expected profit on inside information less than in an otherwise identical market.

It is my view that a Kyle-type of security market model is a good starting point for the study of insider trading, and in chapter 2 - 8, I extend it to a setting more appropriate for analyzing insider trading and its regulation. In doing this, I have benefitted from many of the existing extensions, for instance, Admati and Pfleiderer (1988), Subrahmanyam (1992), Spiegel and Subrahmanyam (1992), and, especially, Fishman and Hagerty (1992). Their models are special cases of the models characterized by lemma 2.1, lemma 7.1, and lemma 8.1 in subsequent chapters.

Financial market models focusing explicitly on insider trading regulations

In recent years, trading by corporate insiders and the regulation of such trades have been analyzed in models specially designed for this purpose. Examples are found in Grinblatt (1986), Manove (1989), Dennert (1989), Ausubel (1990), Fishman and Hagerty (1992), and Leland (1992). Here I concentrate on the last two.

Fishman and Hagerty (1992) analyze insider trading in a Kyle-type of model with two types of informed speculators, a single corporate insider and several market professionals. There are also liquidity traders who are trading to satisfy their liquidity needs, and market makers whose duty it is to clear the auction by taking the net opposite position. They find that insider trading may have two adverse effect on the competitiveness of the financial market; it deters other traders from acquiring information, and thereby skews the distribution of information held by traders towards one trader, which suggests that insider trading may lead to less efficient stock prices. To outsiders, such as potential entrants into the industry, it means that the market price cannot be trusted as much as basis for decisions whether to enter into the same line of business or not.

In Leland (1992), insider trading is analyzed within a rational expectations framework. The demand for shares comes from a single insider who observes perfect information and recognizes his impact on the transaction price, from outside arbitrageurs who trade on information generated by observing the market price, and from liquidity traders who are trading randomly. The supply comes from the firm which issues shares to maximize the expected profit of current shareholders. Leland shows that when insider trading is permitted, the average stock price will be higher, the liquidity of the market will be less, the current price will be more volatile, the future price volatility given the current price will be lower, and the current price will be more highly correlated with the future price. He shows that there may be a net gain in welfare due to increased internal efficiency of investments which offsets the cost to outside investors and liquidity traders. The opposite is the case if the investments are inflexible.

These articles give no clear conclusion whether insider trading should be prohibited or not. It seems that the net effect on social welfare is ambiguous because there are both positive and negative effects caused by insider trading.

Methodological problems

One of the major problems with the literature focusing on heterogenous information in financial markets, including the models presented in my dissertations, is the rather strong parametric assumptions relative to the ones needed in the extensive literature on financial market with homogenous information (see, e.g., Duffie (1992)).

It is usual to assume that the random variables are normally distributed, and that the preferences of the agents are represented by linear or exponential utility functions (risk neutral or constant absolute risk aversion). Moreover, many of the random variables, e.g., the risky assets, are often assumed to be independent. These assumptions lead to a rather neat linear equilibrium (without any wealth effects) so they are also widely used throughout my dissertation.

The attractiveness of model with heterogenous information is that they give insight into phenomena such as the bid ask spread, the market liquidity, the volatility, and the informativeness of the transaction price which are important to real financial markets. Nevertheless, these new market characteristics complicate the equilibrium relative to the corresponding equilibrium with homogenous information, partly because we have to keep an accurate account of the new concepts.

1.3 ARGUMENTS AGAINST INSIDER TRADING

There has been an academic controversy over insider trading at least since Henry G. Manne in 1966 publicized his insightful book "Insider Trading and the Stock Market" (an earlier reference is Smith (1941)). There he challenges the at that time established view that insider trading is harmful by exhibiting many of the potential positive effects of insider trading. In recent years, the so called insider trading scandals on Wall Street and elsewhere have revitalized the interest of insider trading and its regulation. Dennert (1991) gives an excellent overview of the current state (see also King and Röell (1988)).

According to Scott (1980) and Haft (1982), there are four rationales or categories of arguments for prohibiting insider trading; the fair play, the business property, the informed market (or the external efficiency), and the internal efficiency (see also Charlton and Fischel (1983) and Moore (1990) for discussions along these lines). The arguments are connected, for instance, because the fair play rationale may depend on the property rights of information.

The following presentation of arguments follows along the lines of the four rationales for prohibiting insider trading. It is based on the current state of the insider debate, and includes therefore many arguments which come from and therefore will be looked at more closely in this dissertation.

i) Fair play

This was previously the most common argument in favor of insider trading regulations (see Macey (1984)). It holds that insider trading should be prohibited because it is unfair to take advantage of internal information, knowing it is not available to those with whom the insider is trading. Moral or ethic behavior requires that corporate insiders either abstain or disclose their information before trading in the securities market. There are two versions; one proclaiming that trading on differential information in itself is unfair, the other that trading is unfair only when its sources are not available to all. Insider trading would be unfair according to both. The trades of market professionals would be unfair according to the first, but not according to the second. Finally, a related line of arguments speaks of the traders' confidence. The idea is that if the public believes that the securities market is biased, they will choose not to participate, the market will suffer because of reduced liquidity, and the efficient allocation of capital will be impeded.

ii) Business property

Insider trading should be prohibited because internal information is intended for corporate uses, and not for anyone's personal benefit. A ban on insider trading affords protection of the shareholders' property rights. This suggests that corporate insiders are actually stealing or breaking their fiduciary relationship with their principals, and should be treated accordingly. However, the property right theory implies that if the current shareholders find it in their interests, they could allocate the property rights of inside information to their agents and thereby legalize insider trading. This means that regulation becomes a matter of contract between the shareholders and their employees (see Macey (1984)). If the employment contract forbids an employee from using the company's information, insider trading would be unethical. Then the only reason for not permitting companies to allow their employees to trade on internal information would be that it causes harm to investors outside the firm (potential future owners) or to society at large. It therefore becomes important to identify who are actually harmed by insider trading.

iii) Informed market (or external efficiency)

Insider trading should be prohibited in order to let the stock market perform its functions of security evaluation and capital allocation. For instance, if the corporate insiders have internal information indicating that the company is undervalued, they would be buyers of the company's stock, and realize a profit when the information becomes public. The opposite side of the net order flow is taken by the intermediaries. They would be market makers in a dealership market or broker - arbitrageurs in a market matched by matchmakers. The effect of insiders buying is that the intermediaries' net position is more negative, and their profit is less than it otherwise would be. This is because they have sold stocks to the corporate insiders or due to the insiders' influence on the net order flow. However, the intermediaries are rational and insure their long term profit against losses to better informed traders. They do this in advance by making the terms of trading worse; the buy orders are executed to a higher price, and the sell orders are executed to a lower price than otherwise. If the intermediaries are sufficiently insured, they do not expect to lose at all. The result is that the expected losses are transferred from the intermediaries to the outsiders who are traders like market professionals and liquidity traders. Consequently, the expected trading cost is increased due to corporate insiders trading on superior information. The market professionals also lose because of increased competition among speculators in exploiting non-public information.

Of course, a higher cost of trading reduces the outsiders' demand for shares, and thereby the liquidity of the market (see Leland (1992), page 870). This means that the corporate insiders have an even greater effect on the net order flow, forcing the intermediaries to worsen the terms of trade, increasing the trading cost even more. The result is a self-feeding process, leading to a completely illiquid market. This is the same as saying that trading in the stock is stopped. If the securities market is illiquid, it does not perform its role of effectively allocating risk. Consider a risk averse investor who has realized a large dividend, and wants to hedge his portfolio. This can easily be done by taking an offsetting position in the securities market. However, if insider trading has transferred the uncertainty from the future to the current period due to information signaled to the market through the net order flow, the effectiveness of such a hedging strategy is reduced. In fact, if all uncertainty is transferred to the current period, as would be the case if the market is perfectly illiquid, hedging is not possible. This flight of liquidity which may lead to market breakdowns is the reason that stock market regulators have to prohibit the most highly informed trading, as it easily triggers the self-feeding process towards a collapse. By prohibiting insider trading, the market more easily establishes a liquid and viable long-term equilibrium.

iv) Internal efficiency

Insider trading should be prohibited because it enhances the decision-making precess. Insider trading allows corporate insiders to profit on bad as well as good news, giving an incentive to choose risky projects and surprise the market by delivering less effort than expected. Doing something unexpected generates inside information exploitable for trading (see Leftwich and Verrecchia (1983)). If, for instance, the corporate insiders know in advance that the project is bad in the sense that its outcome is significantly lower than expected, they would sell short and thereby generate a significant profit. The profit increases with the difference between the outcome and its expectation. Consequently, the insiders will chose a risky project in advance because the outcome probably will differ more from its expectation. Insider trading may therefore lead to perverse incentives, and should therefore be prohibited.

1.4 ARGUMENTS FOR INSIDER TRADING

According to Charlton and Fischel (1983), pages 866 - 872, there are two sets of arguments for allocating the property rights of inside information to the corporate insiders and thereby allowing insider trading (see Manne (1966ab) and Shaw (1988)).

i) External efficiency

Corporate insiders who are trading on superior internal information reveal information through their influence on the net order flow. If, for instance, the insiders obtain information indicating that the security of the firm in which they are employed is undervalued, they issue buy orders. This means that there is relatively more buy orders, suggesting that, in order to clear the market, the matchmakers (or the market makers in a dealership market setting) have to increase the transaction price relatively to an otherwise identical market without insider trading. In this way, some of the information originally possessed by the corporate insiders has been transmitted into the market price, and thereby made public. Insider trading is of benefit to outsiders who are trading for reasons other than information (e.g., raise cash, reinvest dividends, chasing trends, etc.), because it reduces their expected trading cost, and therefore improves their welfare. The reason is that when insider trading is allowed, the intermediaries are able to reduce the bid ask spread due to the additional information revealed by increased competition among the superiorly informed traders. If the liquidity traders are risk averse, insider trading also reduces their risk adjusted trading cost, because it brings the transaction price nearer to its underlying fundamental. This reduces the risk of trading, and therefore increases the welfare of liquidity traders.

Prices that reveal information more accurately are beneficiary because they guide the capital investment of the outsiders. If, for instance, potential entrants observe higher prices in an industry in which the market is relatively efficient due to information revealed by insider trading, they infer that this industry is expected to give a high return and enter. In this way, capital has been allocated to the industries which gives the highest returns (see Fishman and Hagerty (1992), pages 113 - 118).

ii) Internal efficiency

The market prices are also signals which direct the choices of capital within the companies themselves. Suppose the return of a company is high in a securities market where insider trading has contributed to a price which is a relatively precise informational statistic, then the managers of that company may infer from the price that the company is profitable. If the managers are differentially informed, the price as a source of information for internal decisions is important. In this way, the managers would increase the investments if the price signals high returns and liquidate unproductive lines of business when the price signals low returns. Hence, insider trading improves this decision because it makers the price a better prediction of the underlying value (see Fishman and Hagerty (1989) and Leland (1992)).

The corporate insiders have of course incentives to acquire non-pubic information because it generates profit by trading in the securities market. One can generally obtain non-public information by a random event or as a result of planned actions. The insiders generate information by supplying actions (productive effort or investment decisions) that surprise the market. If, for instance, the managers are investing in a project giving a higher return than expected, they may buy stock in advance of disclosure and make a nice profit (see Easterbrook (1985) and Dye (1984)). They will not surprise the market negatively because it hurts their long term reputation.

1.5 ARGUMENTS FOR VS ARGUMENTS AGAINST INSIDER TRADING

Proponents of allowing insider trading (among them Henry G. Manne) claim that it increases both the internal and external efficiency and therefore social welfare. On the other hand, proponents of prohibiting insider trading (including spokesmen of the regulatory agencies) claim that it decreases both the internal and external efficiency and therefore social welfare. This dispute between the opposite directions is referred to as the insider trading debate.

As reflected in the insider trading debate, conclusions based on equilibrium models with asymmetric information show that there is a trade-off between both positive and negative effects, making it hard to conclude whether insider trading should be prohibited or not. The strength of the effect must be studied empirically, and may in principle vary from exchange to exchange, and even from security to security and from time period to time period.

My contribution to the insider trading debate

I think that my contribution to the ongoing insider trading debate is to clarify a few but important points. Some of these may have been mentioned, but not to my knowledge formally emphasized in earlier research.

- I recognize competition among the corporate insiders by allowing, for instance, all member of the board of directors to trade when insider trading is allowed, whereas the supply of corporate insiders is only reduced and not necessarily eliminated when insider trading is banned and enforced by the stock market regulators. Most previous research, including Fishman and Hagerty (1992) and Leland (1992), have focused on a situation where there is one insider when insider trading is allowed and zero when insider trading is prohibited.

• I present one of the very few formal models focusing on insider trading as an incentive mechanism (another model is Dye (1984), but his conclusions are affected by risk sharing whereas mine are based solely on effects caused by the incentive to maximize their own expected profit). Manne (1966ab) claims that insider trading is the mechanism for rewarding managerial effort, whereas my results show the opposite.

These are two of main points in my dissertation, the first may be used as an argument in favor and the second as an argument against insider trading.

1.6 EMPIRICAL EVIDENCE

In relation to the insider trading debate, the objective of empirical studies should be to help determining the strength of the effects caused by insider trading and its regulation. However, very few of the empirical studies have this as their primary objective. Most studies motivate the focus on insider trading in order to test strong-form market efficiency. Today, the theoretical development in the area of equilibrium models with asymmetric information has made it possible to form hypotheses which one should be able to test empirically, and we have already observed the first such studies.

Many empirical studies of insider trading are confronted with the problem that information sets are not observable by others than its owners. Analysts have either to use case studies, or they have to use an approximation for the insiders' information sets.

Case studies

One way of analyzing insider trading is for the analyst to become a corporate insider and trade based on inside information. The most famous of these "researchers" are Ivan F. Boesky and Michael R. Milken, who indeed, have shown that it is possible to earn huge sums of money by trading on inside information. Nevertheless, in these cases, the fines, imprisonment, and a destroyed reputation have to be taken into account, hopefully leaving them with no abnormal returns. But it is unlikely that there is an ex post settling up in every case.

Approximations

A different approach is to use an approximation for the insiders' information sets to find out how insider trading affects financial markets. There have mainly been two types of empirical questions based on proxies that have drawn much attention by researchers: What is the extent of insider trading in financial markets, and what is the performance of the identified insiders?

i) Event studies

Presumably, a typical sequence of events is that before it becomes public, firm-specific information is revealed to the corporate insiders. If insiders or their tippees are trading on inside information, they would of course do this before the information is formally disclosed. In this way, one could look at the abnormal return prior to the announcements, and if the abnormal return starts to increase before a disclosure of good news, we could conclude that informed traders were operating on non-public information. The abnormal return would rise because information leaked out through their trades. Clearly, we should be careful when concluding, because a significant part of the informed trading is performed by quasi-insiders such as securities analysts trading legally on private information generated outside the firm from sources which in principle are available to all. To reduce the problem with the quasi-insiders, event studies examining the extent of insider trading should try to identify who is actually trading. One way of doing this is to control against the reported trades of corporate insiders presumably trading for other reasons than inside information.

What events are most likely to tempt the corporate insiders and their tippees to trade illegally on internally generated information? King and Röell (1988) claim, on the bases of the notorious cases of insider trading on both sides of the Atlantic, that advance knowledge of take-over bids are the most important example of unpublished price-sensitive information because the share price of the target tends to rise dramatically (see their pages 179 - 181). One problem is that in this case a possible rise before announcement may also be caused by the bidder's own purchases and has nothing to do with corporate insiders trading illegally, but a sharp price movement is sufficient to generate suspicion. Keown and Pinkerton (1981) analyze the extent of insider trading before merger announcements. They conclude on page 863 that "... this suggests substantial trading upon inside information concerning the prospective merger, beginning approximately one month before the announcement date with uncontrolled abuse of Rule 10b-5 occurring in the five to eleven trading days immediately prior to the announcement date." But on the same page, they say that "... the frantic trading that occurred prior to the merger announcement was not caused by registered insiders for whom trades during this period would attract unwanted attention. The absence of registered insider trading combined with the dramatic increase in volume suggests that much insider trading is carried out through third parties so as to escape detection." Keown and Pinkerton may be right, but I think they fail to recognize the role of market professionals who as part of their work should look for signals revealing possible merger candidates. Mergers and insider trading has also been studied by, e.g., Elliott, Morse, and Richardson (1984) and Givoly and Palmon (1985) who confirm that registered insiders do not want to be incriminated by increasing their reported activity before mergers.

Among the other events tested are announcements of earnings (Elliott, Morse, and Richardson (1984) and Givoly and Palmon (1985)), forecast of earnings (Penman (1982, 1985) and Givoly and Palmon (1985)), dividends (Elliott, Morse, and Richardson (1984), Givoly and Palmon (1985), and John and Lang (1991)), bond ratings (Elliott, Morse, and Richardson (1984)), new issues (Karpoff and Lee (1988)), and bankruptcies (Elliott, Morse, and Richardson (1984), Loderer and Sheehan (1989), and Gosnell, Keown, and Pinkerton (1992)). Most of these studies use reported insider transactions to control that the information leakages actually came from the corporate insiders. Some find significant indications of insiders timing their trades relative to these events, others find no or a very weak connection.

A related approach is to look for insider trading before large changes in stock prices. Reinganum (1988) and Seyhun (1990) find no insiders trading before such events using the reported insider transactions as a proxy for insider trading (see also Netter and Mitchell (1989)). Seyhun (1988) analyzes whether there is a relation between market movements and aggregate insider trading, and concludes that insider trading sometimes is motivated by economy-wide factors.

ii) Performance studies

As long as the trades of corporate employees are based on other motives than inside information, they may trade perfectly legally in the securities of the company in which they are employed. However, on most stock market exchanges these trades have be reported to the control authorities. These trades (e.g., in the USA reported in the SEC's Official Summary of Insider Trading) may be used to test whether insiders earn an abnormal return, and they may be linked to events to find out whether the insiders trade illegally on inside information. The return in such studies gives the lower limit of what insiders trading on inside information may expect to achieve.

Performance studies find that insiders earn an average excess return of 5 - 10% over the year following the transaction; see, e.g., Lorie and Niederhoffer (1968), Pratt and DeVere (1972), Jaffe (1974ab), Finnerty (1976ab), Baesel and Stein (1979), Givoly and Palmon (1985), Seyhun (1986), Heinkel and Kraus (1987), King and Röell (1988), Rozeff and Zaman (1988), Lin and Howe (1990), and Pope, Morris and Peel (1990). If transaction costs are taken into account, the net returns become significantly lower. Outsiders obtain no abnormal return by mimicking the insiders.

Some other relevant studies

Stoll (1989) finds that the quoted bid ask spread contains a large and statistically significant adverse selection or informational asymmetry component; see also Glosten and Harris (1988) and George, Kaul, and Nimalendran (1991). This confirms that there is trading based on non-public information. However, it is very difficult to measure how much of this should be attributed to corporate insiders. Masson and Madhavan (1991) examine whether insider trading by a firm's top executives raises or lowers firm value. They find support for the hypothesis that active use of inside information lowers firm value. However, greater stock ownership by executives raises firm value. Torabzadeh, Davidson, and Assar (1989) find that two of the insider trading scandals on Wall Street (the Levine and Boesky cases) had a negative effect on risk adjusted stock returns of eleven major publicly traded securities. Finally, Kabir and Vermaelen (1991) study the introduction of insider trading restrictions on the Amsterdam Stock Exchange. They conclude that after the trading restrictions, stocks became less liquid but the speed of the adjustments to new announcements was not altered.

Summary

The empirical literature suggests that insider trading is a part of the trading activity in financial markets, and it affects the properties of the securities market and thereby the welfare of all its participants. This means that it is important to get a deeper understanding of how insider trading affects the market and thereby the welfare of all its participants.

1.7 REGULATION

One of the major tasks of financial market regulators, whose duty it is to regulate trading on inside information, should be to design an appropriate regulatory framework given the theoretical and empirical implications outlined above. This section summarizes the basic premises for successful regulation and enforcement, and gives a short overview over the existing legislation in Europe (especially United Kingdom and Norway), the USA, and Japan.

Should insider trading be prohibited?

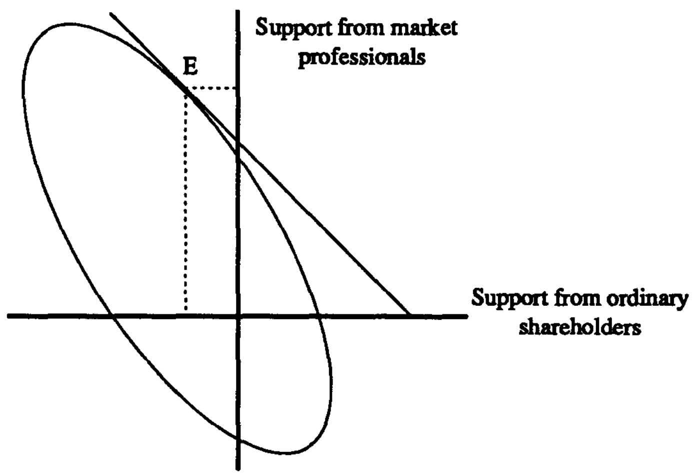
The problem faced by stock market regulators is whether insider trading should be prohibited or not. An individual prefers a change in the securities market law if his or her expected welfare increases. If all the individuals prefer the change, it is said to be Pareto-optimal. Usually, this is not possible when the legislation changes from allowing to prohibiting insider trading because the corporate insiders who are forced out of the market lose. A criterion that a regulatory change should be Pareto-optimal would not lead to any implementation of a law prohibiting insider trading. This suggests, because we actually observe regulatory changes, that stock market regulators use some welfare function to decide whether to implement and enforce a law restricting the trades of corporate insiders. For a given set of welfare weights, the law should be implemented if its benefits dominate its harmful effects.

Optimal enforcement

If it is optimal to prohibit insider trading, the financial market regulators often establish an agency (like the SEC in the USA) whose duty it is to enforce the ban by catching corporate insiders trading illegally. It may, however, be very difficult to catch and punish the insiders or their tippees, because they may easily hide behind the outsiders in the order flow. As a result, it is very costly to enforce the law which may suggest that a significant number of corporate insiders is "allowed" to trade illegally. This means that the real choices of regulators are to allow insider trading or ban it with an enforcement which does not always prevent all the corporate insiders from trading.

Haddock and Macey (1987) analyze a model which suggests that regulatory actions, including the decision of the enforcement agency, will divert wealth from relatively diffuse groups toward more coalesced groups whose members have strong individual interests in the effects of regulations. They argue that active traders such as market professionals form well defined organizations whereas inactive traders often are disorganized. The regulators changing the law or its enforcement practice therefore face either strong opposition or strong support from the organizations of the active traders, and less such activity from the less active traders. Figure 1.2 gives an example.

FIGURE 1.2: Support maximization



The area outlined shows the policy selection opportunity set of the regulatory agency defined by the regulators and the courts. It can be of virtually any shape, but is here drawn so that the interests of the two groups are negatively correlated. To maximize support, the regulatory agency will have to select the policy represented by E. In optimum, the slope of the frontier of the opportunity set is minus forty-five degrees, reflecting that the regulatory agency value support from market professionals as much as from ordinary shareholders. We see that in this example, the enforcement agency faces support from the market professionals and opposition from the ordinary shareholders.

In chapter 4, I show that the market professionals tend to prefer insider trading outlawed whereas the liquidity traders tend to prefer it allowed. If the law prohibits insider trading, the regulators will be supported by the professionals and not by the liquidity traders. The enforcement agency determine how many corporate insiders that are "allowed" to trade illegally when it determines how much resources to spend on enforcement. If the agency wants to implement restrictive and costly policies, it faces support from market professionals and opposition from liquidity traders (see chapter 5).

Regulation on major stock exchanges

Insider trading is prohibited on most highly developed stock market exchanges. The short presentation given in this subsection is based on Gaillard (1992) who gives a detailed overview of the insider trading laws in Europe, the United States, and Japan.

i) USA

The law in the United States relating to insider trading has developed by statutory enactment, common law interpretation, and regulatory promulgation. The legislation is primarily a matter of federal law where the primary underlying prohibitions that are construed by the Congress to forbid insider trading are found in §§ 10(b) and 14(e) of the Securities Exchange Act of 1934 and § 17(a) of the Securities Act of 1933. Nevertheless, none of these sections mention insider trading explicitly, but refer more generally to fraud. Their application to trading on inside information is due to judicial interpretation and the regulations of the Securities and Exchange Commission such as the SEC rules 10b-5 and 14e-3.

The so called scandals on Wall Street during the 1980s lead to widespread calls for amendments to the federal securities sanctions aimed at deterring insider trading offenses and to increase the enforcement powers of the SEC. To satisfy the demand for more regulations, the Insider Trading Sanctions Act of 1984, the Insider Trading and Securities Fraud Enforcement Act of 1988, and the Securities Law Enforcement and Penny Stock Reform Act of 1990 were enacted. This means that the law of the United States today includes a wide range of civil, administrative and criminal sanctions applicable to violations of the insider trading laws and regulations, and the SEC has enlarged its authority with investigative and enforcement powers to execute its regulatory mandate.

The sanctions for insider trading fall into three categories: civil sanctions and administrative remedies available in proceedings brought by the SEC, criminal sanctions available in prosecutions brought by the Justice Department, and remedies available to private litigants in civil actions. According to section 32(a) in the Exchange Act, the maximum jail sentence for violations of the federal securities law is ten years, and the maximum fine is $1 million dollars for individuals and $2.5 million for institutions. In addition, the courts are permitted according to § 21A of the Exchange Act to impose a civil penalty of up to three times the trading gains made, or losses avoided. Several insiders have been prosecuted and convicted (see United States v. Boesky (3 years imprisonment and $100 millions in fines), United States v. Levine ($11.5 millions in fines, and United States v. Milken (10 years imprisonment and $600 millions in fines) for some cases from the period 1985 - 1990).

ii) Europe

Insider trading is prohibited on most exchanges in Western Europe. Insider trading is prohibited in France since 1970, United Kingdom 1980, Norway 1985, Sweden 1985, Denmark 1987, Greece 1988, Finland 1988, Switzerland 1988, Austria 1989, Belgium 1989, Netherlands 1989, Liechtenstein 1989, Ireland 1990, Italy 1991, Luxembourg 1991, Portugal 1991, and in Spain since 1991. Only Germany has yet to enact a legally binding regulatory regime to replace or supplement its existing voluntary Insider Trading Guidelines. In addition to national legislation, insider trading is also regulated internationally. Directive 89/592 coordinates EEC regulations in this field, and the Council of Europe in Strasbourg has opened for signature an international treaty, called the Convention on Insider Trading. The first country to sign was Norway followed by the United Kingdom and Sweden.

The leading stock exchange in Europe is the London Stock Exchange. Consequently, I identify more closely the insider trading regulation in the United Kingdom. The criminal prohibition of insider trading is contained in the Company Securities (Insider Dealing) Act 1985, but see also the Financial Service Act 1986 for implications for the control of insider trading. In addition to legislation, there are a number of Codes of Conduct which have been promulgated by various self-regulatory bodies such as the Conduct of Business Rules and Core Rules by the Securities and Investments Board, the City Code on Takeovers and Mergers, and the Model Code for Securities Transactions by Directors of Listed Companies. A person accused of insider trading may be tried by a Magistrates Court or upon indictment in the Crown Court. In the Magistrates, he may be sentenced to up to 6 months in prison or to a fine not exceeding the statutory maximum or both. If convicted upon indictment, he can be sentenced to imprisonment for up to 7 years or to an unlimited fine or both. Several insiders are prosecuted and convicted (see, e.g., The Times, 1st May 1991, about the case R v. Goodman. Goodman pleaded guilty and was sentenced to 18 months imprisonment, half of which was suspended).

In Norway, insider trading is prohibited according to the Securities Exchange Act of 1985 No. 61 section 6, 6a, and 6b. Section 62 contains penal sanctions such that corporate insiders and their tippees who are breaking the law may be punished by fines or imprisonment or both. For violating § 6, the maximum imprisonment is 6 years; there is no maximum fine. No case has as yet been brought to courts, but several cases have been investigated. One case is expected to be tried for courts in 1993.

iii) Japan

From 1988, insider trading is regulated by the 1948 Securities Act where its Articles 58, 190-2, and 190-3 prohibit insider trading (see also articles 154, 188, and 189). A person who violates the provisions 190-2 and 190-3 is subject to imprisonment for up to six months and/or a fine of up to ¥500,000. Violations of the more general article 58 are punishable by imprisonment for not more than three years and/or a fine of not more than ¥3 millions. It does not mention insider trading explicitly, but refer to fraud in general. There has been no cases brought to court, but at least some cases have been investigated by the authorities.

Summary

The regulation of insider trading is extensive. It is therefore important to understand how these regulations work in financial markets by considering that the number of corporate insiders may be reduced, and not necessarily eliminated by banning insider trading.

1.8 AN OVERVIEW OF THE SUBSEQUENT CHAPTERS

This dissertation is organized in five parts. The first part gives an introduction to the insider trading debate, and the second part develops the basic model and analyzes its properties. Parts three and four extend the basic model by taking into account the production side of the economy and factors such as the market power in the broker - dealership market and risk aversion. Finally, part five summarizes the dissertation, and gives some policy recommendations based on the developed theory.

PART I INTRODUCTION

The dissertation starts with an introduction to the insider trading debate, raising theoretical, empirical, and judicial issues.

Chapter 1 On the Desirability of Insider Trading Regulations in Financial Markets: A Review Essay

The debate whether insider trading should be prohibited or not is the topic of this dissertation. This chapter offers a short review of the arguments for and against regulation, surveys the empirical literature, and discusses briefly the regulation on some major stock exchanges. Finally, an overview of the subsequent chapters is given.

PART II BASIC MODEL AND ITS PROPERTIES

A simple exchange economy with insider trading is developed and analyzed. The focus is on what happens to the properties of the economy and the welfare of its participants when the supply of corporate insiders changes exogenously due to a shift in the law governing insider trading or the enforcement intensity of the stock market regulators.

Chapter 2 Models of Imperfectly Competitive Markets with Insider Trading

This chapter is technical and its major purpose is to derive a security market equilibrium which takes into account presence and absence of corporate insiders. It is used in chapters 3 - 4 as a first approach to analyze the effects of insider trading in financial markets. Later chapters extend the outlined framework to capture other elements relevant for the insider trading debate.

Chapter 3 On the Properties of Financial Markets with a Changing Supply of Corporate Insiders

Under certain condition, insider trading causes the trading intensities of all superiorly informed traders to decrease and thereby reduces the equilibrium bid ask spread. On the other hand, it increases the market depth, the expected trading volume, the volatility, and the informativeness of the transaction price. This is a flavor of the numerous and rather complex effects which have to be taken into account when stock market regulators propose changes in the law governing the trades by corporate insiders.

Chapter 4 Welfare Effects Caused by a Changing Supply of Corporate Insiders

Insider trading is shown to affect the expected profit of security traders such as market professionals and liquidity traders. I identify two effects; one caused by competition and the other by adverse selection. First, if the trader is motivated by liquidity events, the competition in exploiting superior information is zero. If, on the other hand, the trader is motivated by privately acquired information, the competition increases with the supply of corporate insiders, leading to less expected profit. Secondly, the adverse selection effect works indirectly through the problem of differentiating the informed from the uninformed, faced by the price setting market makers. If one insider enters, the adverse selection problem is increased. The result is a negative effect on the expected profit of both the liquidity traders and the market professionals. However, if the supply expands further, the adverse selection decreases due to competition among the informed. The result is a positive effect on the expected profits of all traders. In this way, the total effect is a trade-off between these effects. I conclude that the market professionals tend to prefer insider trading prohibited, whereas the liquidity traders tend to prefer insider trading allowed. Nevertheless, they tend to agree that the worst case is to have an insider trading law which is not adequately enforced by the stock market regulators.

As we have seen, chapter two develops the exchange economy, chapter three analyzes its properties, and chapter four analyzes welfare effects.

PART III PRODUCTION

I extend the exchange economy analyzed in part two to a corresponding economy where the corporate insiders are considered to be corporate employees who supply an effort to the firms in which they are employed. This means that insider trading in the financial market may influence production.

Chapter 5 On Production, Disclosure, and Insider Trading Regulations

A change in the supply of corporate insiders is shown to affect the expected welfare of current shareholders by causing information, production, and enforcement cost effects. My analysis indicates that if the negative production effect is very strong, it quickly tends to dominate the positive information and cost effects. In such a market, I conclude that insider trading is not desirable as it gives corporate managers an incentive to act in their own interests and not in the interest of their principals. They do this by shirking their duty as suppliers of productive effort. In this way, insider trading is really an agency problem.

Chapter 6 Insider Trading on Effort Generated Information

I examine insider trading as a mechanism promoting managerial effort. My findings show that trading on effort generated information promotes an equilibrium supply of effort that is either incentive compatible or destructive. This is because corporate managers of higher than average quality are motivated to supply an effort higher than expected, and, symmetrically, the managers of lower than average quality find it easier to surprise the market by supplying an effort less than expected. In this way, effort is random which generates superior information unavailable to outsiders. I compare the expected effort and its volatility when insider trading is the sole incentive mechanism with a corresponding market where insider trading is prohibited. The managers are instead motivated by a linear outcome-contingent incentive scheme. My results indicate that insider trading is not desirable as an incentive mechanism because the linear outcome-contingent scheme produces a higher expected effort and reduces the volatility of the effort choices.

Roughly speaking, the difference between these two chapters is that chapter five focuses on the effects influencing the expected production whereas chapter six develops a theory which explores the effects on its variance. Nevertheless, there is a close link between the two.

PART IV OTHER EXTENSIONS

This part extends the analyzes in part two to a corresponding economy where all the participants are risk averse and where there is market power in the broker - dealership market. Incentive effects are ignored.

Chapter 7 Insider Trading in an Imperfectly Competitive Market with Risk Averse Agents

A change in the security market law from allowing to banning insider trading is shown to affect the expected profit and the risk exposure of all the traders. Take, for instance, the uninformed and semi-rational liquidity traders whose welfare depends on their expected trading costs and the risk of trading at a price different from the future value of the security. The expected trading cost is determined by the equilibrium bid ask spread and their trading volume, where the spread depends on adverse selection and risk compensation. As in previous chapters, the adverse selection component is caused by the price differentiation problem of market makers. It may either increase or decrease with the supply of corporate insiders, depending on the change in the insiders' market power. However, the risk compensation component is caused by the aversion of market makers towards variations in the price deviation. It is shown to be reduced by insider trading. This is because corporate insiders improve the informativeness of the pooled order flow, and thereby reduce the risk of taking the opposite position vis-à-vis the traders. Insider trading has also a desirable effect on the liquidity traders' risk premium because corporate insiders tend to bring the transaction price nearer to its underlying value based on privileged information. This suggests that the welfare of liquidity traders are improved by intensive insider trading.

Chapter 8 Hedging, Arbitrage and Dealing in a Securities Market with Insider Trading Regulations

This chapter focuses on the welfare effects of insider trading regulations in a simple exchange market where the intermediaries recognize their market power. Take, for instance, the uninformed hedgers whose welfare is shown to depend on their initial position and the net gain from hedging. The sign and the size of the gain depends on the effectiveness of the hedging strategy and its implementation costs. Insider trading transfers resolution of uncertainty from the future to the present period, and thereby reduces the effectiveness of hedging strategies via the so called Hirshleifer effect. This is because insider trading reveals information to the intermediaries. They are then able to set the transaction price nearer its underlying fundamental, making it hard to hedge the future value of the security by taking offsetting positions in the securities market. On the cost side, there are two effects. Insider trading widens the equilibrium bid ask spread because of increased adverse selection due to less hedging. This erodes market liquidity. On the other hand, insider trading decreases the trading risk because it brings the transaction price nearer to its underlying fundamental. The net effect depends on the trade-off between the Hirshleifer effect, which reduces the effectiveness of hedging, and the two cost effects working opposite of each other. I find that the Hirshleifer effect tends to dominate, and conclude that hedgers tend to prefer insider trading prohibited and enforced by the stock market regulators.

The difference between these two chapters is that chapter eight extends the model developed in chapter seven to a corresponding economy where there are rational hedgers replacing the semi-rational liquidity traders. In addition, imperfect competition in the dealership market is allowed.

PART V CONCLUSIONS

This part concludes the dissertation and draws attention to future research possibilities, both empirical and theoretical ones.

Chapter 9 Summary of Major Conclusions

This chapter gives a short overview over the major conclusions in chapters 2 - 8. It is done by giving concrete advice on how the stock market regulators, the various types of outsiders, and the corporate insiders should adjust to insider trading or its regulation.

1.9 SUMMARY

The desirability of insider trading regulations in financial markets depends on a rather complex trade-off among several effects working on the social welfare function. In my opinion, there is no obvious conclusion because the net effect is ambiguous. Nevertheless, my personal view is that if insider trading is to be prohibited, which often seems to be optimal, the prohibition should be enforced adequately by forcing the corporate insiders out of the security market. Insider trading should be rather rare events which presumably is not the case today at several exchanges.

REFERENCES

Admati, A. R., 1989, "Information in Financial Markets: The Rational Expectations Approach," Discussion in S. Bhattacharya and G. M. Constantinides, "Financial Markets and Incomplete Information: Frontiers of Modern Financial Theory," Volume 2, Rowman and Littlefield, 139 - 152.

Admati, A. R., 1991, "The Informational Role of Prices: A Review Essay," Journal of Monetary Economics, 347 - 361.

Admati, A. R., and P. Pfleiderer, 1988, "A Theory of Intraday Patterns: Volume and Price Variability," Review of Financial Studies, 3 - 40.

Ausubel, L. M., 1990, "Insider Trading in a Rational Expectations Economy," American Economic Review, 1022 - 1041.

Charlton, D. W., and D. R. Fischel, 1983, "The Regulation of Insider Trading," Stanford Law Review, 857 - 895.

Dennert, J., 1989, "Insider Trading and the Allocation of Risks," Working Paper, University of Basel.

Dennert, J., 1991, "Insider Trading," Kyklos, 181 - 202.

Dye, R., 1984, "Insider Trading and Incentives," Journal of Business, 295 - 313.

Duffie, D., 1992, "Dynamic Asset Pricing Theory," Princeton University Press.

Easterbrook, F. H., 1985, "Insider Trading as an Agency Problem," Chapter 4 in J. Pratt and R. Zeckhauser, "Principals and Agents: The Structure of Business," Harvard Business School Press, 81 - 100.

Elliott, J., D. Morse, and G. Richardson, 1984, "The Association between Insider Trading and Information Announcements," Rand Journal of Economics, 521 - 536.

Finnerty, J. E., 1976a, "Insiders and Market Efficiency," Journal of Finance, 1141 - 1148.

Finnerty, J. E., 1976b, "Insiders Activity and Insider Information: A Multivariate Analysis," Journal of Financial and Quantitative Analysis, 205 - 215.

Fishman, M. J., and K. M. Hagerty, 1989, "Disclosure Decisions by Firms and the Competition for Price Efficiency," Journal of Finance, 633 - 646.

Fishman, M. J., and K. M. Hagerty, 1992, "Insider Trading and the Efficiency of Stock Prices," Rand Journal of Economics, 106 - 122.

Gaillard, E., 1992, "Insider Trading: The laws of Europe, the United States and Japan," Kluwer Law and Taxation Publishers.

George, T. J., G. Kaul, and N. Nimalendran, 1991, "Estimation of the Bid - Ask Spread and Its Components: A New Approach," Review of Financial Studies, 623 - 656.

Givoly, D., and D. Palmon, 1985, "Insider Trading and the Exploitation of Inside Information: Some Empirical Evidence," Journal of Business, 69 - 87.

Glosten, L. R., and L. E. Harris, 1988, "Estimating the Components of the Bid / Ask Spread," Journal of Financial Economics, 123 - 142.

Glosten, L. R., and P. R. Milgrom, 1985, "Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders," Journal of Financial Economics, 71 - 100.

Gosnell, T., A. J. Keown, and J. M. Pinkerton, 1992, "Bankruptcy and Insider Trading: Differences Between Exchange-Listed and OTC firms," Journal of Finance, 349 - 362.

Grinblatt, M. S., 1986, "On the Regulation of Insider Trading," Working Paper, Graduate School of Management, University of California, Los Angeles.

Grinblatt, M. S., and S. A. Ross, 1985, "Market Power in a Securities Market with Endogenous Information," Quarterly Journal of Economics, 1143 - 1167.

Grossman, S., 1989, "The Informational Role of Prices," MIT Press.

Haft, R. J., 1982, "The Effect of Insider Trading Rules on the Internal Efficiency of the Large Corporation," Michigan Law Review, 1051 - 1071.

Heinkel, R., and A. Kraus, 1987, "The Effect of Insider Trading on Average Rates of Return," Canadian Journal of Economics, 588 - 611.

Haddock, D. D., and J. R. Macey, 1987, "Regulation on Demand: A Private Interest Model, with an Application to Insider Trading Regulation," Journal of Law and Economics, 311 - 352.

Jaffe, J. F., 1974a, "The Effect of Regulation Changes on Insider Trading," Bell Journal of Economics and Management Science, 93 - 121.

Jaffe, J. F., 1974b, "Special Information and Insider Trading," Journal of Business, 410 - 428.

John, K., and L. H. P. Lang, 1991, "Insider Trading around Dividend Announcements: Theory and Evidence," Journal of Finance, 1361 - 1389.

Kabir, R., and T. Vermaelen, 1991, "Insider Trading Restrictions and the Stock Market," Working Paper, INSEAD.

Karpoff, J. M., and D. Lee, 1988, "Insider Trading Prior to New Issue Announcements: Empirical Evidence," Working Paper, Graduate School of Business, University of Washington.

Keown, A. J., and J. M. Pinkerton, 1981, "Merger Announcements and Insider Trading Activity: An Empirical Investigation," Journal of Finance, 855 - 869.

Kyle, A. S., 1984, "Market Structure, Information, Futures Markets, and Price Formation," In G. G. Storey, A. Schmitz, and A. H. Sarris, eds., "International Agricultural Trade: Advanced Readings in Price Formation, Market Structure, and Price Instability," Westview Press, 45 - 64.

Kyle, A. S., 1985, "Continuous Auctions and Insider Trading," Econometrica, 1315 - 1335.

Kyle, A. S., 1989, "Imperfect Competition, Market Dynamics, and Regulatory Issues," Discussion in S. Bhattacharya and G. M. Constantinides, "Financial Markets and Incomplete Information: Frontiers of Modern Financial Theory," Volume 2, Rowman and Littlefield, 153 - 161.

Laffont, J. J., and E. S. Maskin, 1990, "The Efficient Market Hypothesis and Insider Trading on the Stock Market," Journal of Political Economy, 70 - 93.

Leftwich, R. W., and R. E. Verrecchia, 1983, "Insider Trading and Managers` Choice Among Risky Projects," Working Paper #63, Centre of Research in Security Prices, Graduate School of Business, University of Chicago.

Leland, H. E., 1992, "Insider Trading: Should it be Prohibited?" Journal of Political Economy, 859 - 887.

Lin, J. C., and J. S. Howe, 1990, "Insider Trading in the OTC Market," Journal of Finance, 1273 - 1284.

Loderer, C. F., and D. P. Sheehan, 1989, "Corporate Bankruptcy and Managers' Self-Serving Behavior," Journal of Finance, 1059 - 1075.

Lorie, J. H., and V. Niederhoffer, 1968, "Predictive and Statistical Properties of Insider Trading," Journal of Law and Economics, 35 - 53.

Macey, J. R., 1984, "From Fairness to Contract: The New Direction of the Rules Against Insider Trading," Hofstra Law Review, 9 - 64.

Manne, H. G., 1966a, "Insider Trading and the Stock Market," Free-Press.

Manne, H. G., 1966b, "In Defense of Insider Trading," Harvard Business Review, 113 - 122.

Manove, M., 1989, "The Harm from Insider Trading and Informed Speculation," Quarterly Journal of Economics, 823 - 846.

Masson, R. T., and A. Madhavan, 1991, "Insider Trading and the Value of the Firm," Journal of Industrial Economics, 333 - 353.

Moore, J., 1990, "What is Really Unethical About Insider Trading?" Journal of Business Ethics, 171 - 182.

Netter, J. M., and M. L. Mitchell, 1989, "Stock-Repurchase Announcements and Insider Trading Transactions After the October 1987 Stock Market Crash," Financial Management, Autumn, 84 - 96.

Penman, S. H., 1982, "Insider Trading and the Dissemination of Firms' Forecast Information," Journal of Business, 479 - 503.

Penman, S. H., 1985, "A Comparison of the Information Content of Insider Trading and Management Earnings Forecasts," Journal of Financial and Quantitative Analysis, 1 - 17.

Pope, P. F., R. C. Morris, and D. A. Peel, 1990, "Insider Trading: Some Evidence on Market Efficiency and Directors' Share Dealings in Great Britain," Journal of Business Finance and Accounting, 359 - 380.

Pratt, S. P., and C. W. DeVere, 1972, "Relationship between Insider Trading and Rates of Return for NYSE Common Stock, 1960-66," In J. Lorie and R. Brealey (eds.) "Modern Developments in Investment Management," Dryden Press.

Reinganum, M. R., 1988, "The Anatomy of a Stock Market Winner," Financial Analysts Journal, March-April, 16 - 28.

Röell, A., and M. King, 1988, "Insider Trading," Economic Policy, 165 - 187.

Rozeff, S. M., and M. A. Zaman, 1988, "Market Efficiency and Insider Trading: New Evidence," Journal of Business, 25 - 44.

Scott, K. E., 1980, "Insider Trading: Rule 10b-5, Disclosure and Corporate Privacy," Journal of Legal Studies, 801 - 818.

Seyhun, H. N., 1986, "Insiders Profits, Cost of Trading, and Market Efficiency," Journal of Financial Economics, 189 - 212.

Seyhun, H. N., 1988, "The Information Content of Aggregate Insider Trading," Journal of Business, 1 - 24.

Seyhun, H. N., 1990, "Overreaction or Fundamentals: Some Lessons from Insiders` Response to the Market Crash of 1987," Journal of Finance, 1363 - 1388.

Shaw, B., 1988, "Should Insider Trading Be Outside the Law?" Business and Society Review, 34 - 37.

Smith, F. P., 1941, "Management Trading, Stock Market Prices and Profit," Yale University Press.

Spiegel, M., and A. Subrahmanyam, 1992, "Informed Speculators and Hedging in a Noncompetitive Securities Market," Review of Financial Studies, 307 - 329.

Stoll, H. R., 1989, "Inferring the Components of the Bid - Ask Spread: Theory and Empirical Tests," Journal of Finance, 115 - 134.

Subrahmanyam, A., 1991, "A Theory of Trading in Stock Index Futures," Review of Financial Studies, 17 - 51.

Torabzadeh, K. M., D. Davidson, and H. Assar, 1989, "The Effect of the Recent Insider-Trading Scandal on Stock Prices of Securities Firms," Journal of Business Ethics, 299 - 303.

PART II

BASIC MODEL AND ITS PROPERTIES

CHAPTER 2

MODELS OF IMPERFECTLY COMPETITIVE MARKETS WITH INSIDER TRADING

First draft: October 1990,

Current revision: January 1993.

ABSTRACT

This chapter is technical and its major purpose is to derive a securities market equilibrium which takes into account both presence and absence of corporate insiders. It is used in chapters 3 - 4 as a first approach to analyze the effects of insider trading in financial markets. Later chapters extend the outlined framework to capture other elements relevant for the insider trading debate.

2.1 INTRODUCTION

Asymmetric information in financial markets was first analyzed in simple exchange settings where risk averse and privately informed speculators take the information content of asset prices as given. In Grossman (1976) and similar models, the number of informed speculators is limited and the price system is fully revealing, because there is no other noise than the uncertainty present in the information received by the speculators. If additional noise is introduced, e.g., by making the supply of the risky assets stochastic as in Grossman and Stiglitz (1980) or by introducing noise traders as in Pfleiderer (1984), the price would be partially revealing. Nevertheless, if the number of informed speculators is infinitely large to justify the initial competitive assumption, the price system would reveal all information even if additional noise is introduced (see Pfleiderer (1984), pages 5 - 7). If the market price is a sufficient informational statistic, there are no incentives for rational traders to acquire costly information because they infer all available information from the transaction prices. This means that the fully revealing equilibrium is not viable (see Grossman and Stiglitz (1980)), and accordingly is unsuitable for analyzing insider trading as there is no difference in expected return between insiders and outsiders.

The securities market could alternatively be modeled with competitive behavior among a limited number of informed speculators in the sense that they consider the information content of prices as given (which might be referred to as a type of Bertrand competition). It turns out that the resulting stock market equilibrium is viable since it is partially revealing, and the price system therefore gives rational traders incentives to acquire and trade on costly information. It is however important to notice that it is risk aversion which limits the informed speculators` positions in the risky assets, and consequently prevents the price system from becoming a sufficient informational statistic. On the other hand, if the informed speculators were risk neutral, the prices would transmit all information even with a limited number of traders because they would trade very large quantities. The problem is that competitive behavior in a finite market is "schizophrenic" as recognized by Hellwig (1980). Despite this criticism, this approach could be chosen when analyzing insider trading since informed trading may possibly influence the stock market equilibrium, which is hardly the case when the prices are fully revealing.

Admati (1989, 1991) and Grossman (1989, chapter 1) give excellent surveys of the competitive rational expectations approach to financial markets. It has recently been criticized by Dubey, Geanakoplos, and Shubik

(1989). Huang and Litzenberger (1988, chapter 9) give a good introduction to financial markets with asymmetric information.

I chose to follow Albert Kyle (1984, 1985a), who uses an alternative and more realistic approach, where the superiorly informed speculators act strategically by trying to influence the information content of the price system to their advantage. It turns out that rational traders maximize expected utility by reducing their trades and therefore the information content of the price system relative to the competitive case discussed above. In addition to risk aversion, strategic behavior *per se* limits the positions of speculators in the risky assets. This means that unlike in the competitive case, privately informed traders may be risk neutral without driving the stock market equilibrium to its fully revealing limit. Kyle (1989) gives an excellent survey of the imperfectly competitive approach to financial markets (see also Admati (1991)), and Glosten and Milgrom (1985) present an approach similar to Kyle (1985a) where both informed and uninformed traders are restricted to trade one unit at the time.

In the multi-period, multi-security market outlined in this chapter, I assume that risk neutral speculators use privately acquired information to determine their trading strategies. They are simultaneously recognizing that they influence the information content of the price system. The informed traders submit their orders, together with the orders from the liquidity traders, to risk neutral market makers who set the equilibrium price according to their price rule. The dealers or market makers cannot observe which type of traders that is trading, and for this reason face a price discrimination problem, referred to as an adverse selection problem to the pricing of securities. This is in short the major element in the securities market approach which I use in the two following chapters to analyze insider trading. Later chapters investigate other effects caused by legal and illegal trading by corporate insiders.

As in Fishman and Hagerty (1992), I split the informed speculators into two sub-groups called market professionals and corporate insiders:

- Market professionals (or smart money investors, for instance, security analysts) are rational outsiders who acquire costly information not yet reflected in the price system. They use this information to determine their allocation of resources among the speculative assets, and therefore expect to earn a supernormal profit.

- Corporate insiders are usually employees (i.e., corporate managers and directors) who have access to privileged information about the prospects of their firm. If insider trading is allowed, rational corporate insiders and their tippees use inside information to determine their demands for the risky assets as they expect to earn an abnormal return. This may, of course, also be the case if insider trading is prohibited, especially in markets where the enforcement of the securities market law is inadequate, leading to illegal trading.

The main difference between the two types of superiorly informed speculators is that the outside professionals observe diverse private information and the corporate insiders observe common privileged information. That is, the market professionals observe one signal each, whereas the corporate insiders share one signal. The precision of inside information is always higher than the precision of privately acquired information. However, since the market professionals observe diverse information, the precision of their total information increases with the number of such smart money investors. Clearly, the insiders observe information correlated with the security-specific return component, and the professionals may either observe firm-specific information as in lemma 2.1, or as is possible in lemma 2.2, information correlated with a common factor influencing the returns of all the assets listed on the exchange.

In addition to superiorly informed speculators such as corporate insiders and market professionals, there are also noise or liquidity traders present in the market. These traders have no private information, and trade for reasons given outside the model. They may, for instance, be trading to raise cash, reinvest dividends, or they may just be chasing trends. As suggested by Admati and Pfleiderer (1988), there are two types of liquidity traders:

- Non-discretionary liquidity traders must trade a particular number of shares at a particular time whatever the market conditions are, and
- Discretionary liquidity traders execute their trades to minimize their expected trading cost by choosing strategically the assets and times to trade.

The liquidity traders may be viewed as an irrational element as they seem to be better off holding the riskless asset. However, since their demand is given exogenously, they may have benefits not realized in our simple market setting. Instead of liquidity traders, I could use a stochastic supply of securities to create the adverse selection problem of pricing.

The final group of individuals in the securities market represents the intermediacy and can be interpreted as either dealers/market makers or arbitrageurs.

- Market makers observe the net order flow, determine the equilibrium price, and clear the market by taking the net opposite position vis-à-vis the traders. Thus, their major function is to provide immediacy so that a trader is able to trade without having to search for another trader willing to take the opposite position in that stock.
- Arbitrageurs are traders who tend to trade away the difference between the market price and its "fundamental". They have rational expectations, and therefore use the information content in the security prices when they are determining their trading strategies. The equilibrium prices are determined by market clearing among the privately informed speculators, the liquidity traders, the arbitrageurs, and the market makers.

I do not need to distinguish between the arbitrageurs and the market makers. The reason is that their presence have exactly the same effect in the model; they both provide immediacy so that buyers or sellers do not have to search for other traders to take the opposite position. I choose an approach with risk neutral market makers, and assume for simplicity that they expect to earn no economic rents because of price taking behavior in the dealership market.

Insider trading can be allowed or prohibited by a law (or a private contract) regulating what corporate insiders are supposed to do in the securities market. I compare the insider trading equilibrium with the corresponding equilibrium without the corporate insiders. In this way, I am able to analyze the effects of insider trading on the behavior and wealth of all individuals present in the market. Moreover, some of the corporate insiders in the model may trade illegally, giving me an opportunity to study the effects of prohibited insider trading.

The securities market equilibrium presented in lemma 2.1 differs significantly from previous models with imperfect competition, but several of them (e.g., Kyle (1985a) and Admati and Pfleiderer (1988)) are limits or special cases. The closest model is that of Fishman and Hagerty (1992), which is a special case of my model with only one corporate insider. My more general approach gives a competition effect which is important when we are evaluating the desirability of insider trading regulations (see chapters 3 - 4). I also present a second equilibrium characterized by lemma 2.2 which really is a special case of lemma 2.1. The model of

Subrahmanyam (1991) is in many respects a special case of the second model. The differences are discussed in more detail after I have presented each of my models. It is possible to generalize the model further, for instance, by extending the number of types observing private information and by letting each signal be observed by any number of speculators. This, however, is beyond the scope of this dissertation.

The balance of this chapter is organized as follows. The next section discusses the assumptions, and the equilibrium is given in section three. Sections four and five discuss two important special cases. Then I simplify and assume that the two types of informed speculators observe uncorrelated information. Section six outlines the assumption and presents the resulting equilibrium. The following section shows that the same equilibrium is possible to obtain in a setting where the market makers are replaced by broker - arbitrageurs. In section eight two extensions are discussed. Section nine summarizes the research approach, and formal proofs are found in the appendices.

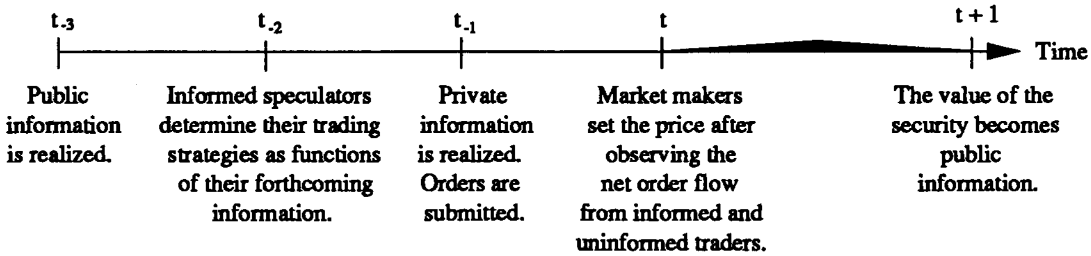
2.2 ASSUMPTIONS

I draw as mentioned on the securities market approach originally proposed by Albert Kyle (1984, 1985a) and outlines an imperfectly competitive securities market with some additional properties which include several securities listed and traded sequentially by several types of traders. The model is used, according to the objective of this dissertation, to describe and later, in chapters 3 - 5, to analyze security trading on superior internal information.

Sequence of events

Figure 2.1 illustrates the time structure around the (call) auction at time $t \in \{0, 1, ..., T_k-1\}$ where t_1 means just before time t, t_2 means just before time t_1, and so on.

FIGURE 2.1 Sequence of events



At time t_{-3}, a public signal is revealed to all the individuals. Then at time t_{-2}, the speculators determine their trading strategies as functions of their forthcoming information. At time t_{-1}, the superior information is realized and the market orders from the informed traders are submitted, together with orders from the uninformed traders, to the price setting market makers. Then at time t, the dealers or market makers observe the net order flow, set the transaction price, and clear the market by taking the net opposite position. Finally, at time t+1, the value of the security becomes public. In this way, the model is characterized by batch trading (see section 2.8 for comments on the extension to continuous trading).

Securities

I assume that at time t there are $K_t + 1$ securities listed on the stock market exchange; K_t risky securities and one riskless bond. At time 0, the value of the riskless bond is one. However, at time t, the bond value increases from $R_{t-1} = (1 + r)^{t-1}$ to $R_t = (1 + r)^t$ where $r \geq 0$ is the riskless rate of return from time t-1 to time t. Cash is assumed to be in perfectly elastic supply. If there is no public signal realized at time t_{-3}, the public pre-trade value of security $k \in \{1, 2, ..., K_t\}$ at time t is[1]

$$(2.1) \qquad m_t = m_0 + \sum_{\tau=1}^{t} d_\tau,$$

where $m_0 > 0$ is the face value of security k and $\Sigma\, d_\tau$ is the change in value from 0 to t (which equals the sum of the value changes from period to period). The face value was paid to firm k at time 0, and the total value

[1] I drop the subscript k,t throughout this dissertation unless it is necessary to clarify.

change equals the sum of the value changes in each period from 0 to t. Some of the realized value could, of course, be paid out to the shareholders as dividends without altering anything in the model but m_x. As in Admati and Pfleiderer (1988), private information about the future value of the security is assumed to be short lived which means that it is never optimal to store information to later periods as it becomes public after one period (see section 2.8 for further comments). At time t+1, the value of security k equals

$$(2.2) \qquad \tilde{x} = m_x + \tilde{d},$$

where the innovation or the period's value change

$$(2.3) \qquad \tilde{d} \sim N(0, \delta).$$

That is, the value change from t to t+1 is normally distributed with mean 0 and variance δ. The dividend paid at time $t \in \{0, 1, ... T_k\text{-}1\}$ is zero, and, at the horizon T_k, firm k is liquidated and the liquidating dividend is consumed by the shareholders.

Information structures

At time t_{-3}, all the participants are assumed to observe a common information signal correlated with the future value of asset k. It may be interpreted as a preliminary income budget disclosed to the stock market prior to trading. The budget is represented by a random variable

$$(2.4) \qquad \tilde{y}^* = \tilde{x} + \tilde{g},$$

where the noise term

$$(2.5) \qquad \tilde{g} \sim N(0, \gamma).$$

This means that if $\gamma \to \infty$, the public signal is only noise (and therefore useless), but as long as $\gamma < \infty$, y^* is informative.[2] In addition to the public signal, the distributive and structural assumptions are common knowledge.

In the same way, private information observed by the informed speculators are represented by random variables correlated with the future value of the risky assets. A realization of a signal tells the speculators who observe it, that some states are more likely to happen than others. Informed traders update their probability assessments of the payoff according to Bayes rule. As in Fishman and Hagerty (1992), there are two types of privately informed speculators; market professionals (or smart money investors, e.g., securities analysts) and corporate insiders.

At time t_1, the corporate insiders managing firm k are assumed to observe common private information correlated with the value of security k at time t+1. Common information means that there is one signal shared by all who observe it. This implies that insider m $\in$ {1, 2, ..., M} observes a signal

$$\tilde{y} = \tilde{x} + \tilde{h}, \tag{2.6}$$

where

$$\tilde{h} \sim N(0, \eta). \tag{2.7}$$

The inside information is about business fluctuations outside the direct control of the corporate insiders. This implies that there is no information generated by the insiders' choice of effort. In this way, the corporate insiders choose the action or effort expected by the market such that the value of the information generated by their actions is zero. In chapter 6, I extend this market to one where the corporate insiders randomize their effort to generate inside information.

The market professionals analyzing security k observe diverse private information represented by a random variable correlated with the future value at time t+1. Diverse information means that each individual who observes such information observes one personal signal, but all the signals have the same precision. Thus, professional n $\in$ {1, 2, ..., N} observes a signal

[2] I drop the tilde when referring to a stochastic variable in the text, but the distinction between a stochastic variable and its realization is used in numbered mathematical expressions like (2.11) below.

(2.8) $$\tilde{y}_n = \tilde{x} + \tilde{e}_n,$$

where the noise term

(2.9) $$\tilde{e}_n \sim N(0, \varepsilon).$$

This implies that the precision or quality of the market professionals' common information increases with their number. However, I assume that

(2.10) $$\gamma > \varepsilon > \eta \geq 0.$$

The public observe a noisier signal than the professionals, who again observe noisier information than the insiders. The error terms are assumed to be uncorrelated. Alternatively, Krishnan and Caballé (1990) analyze a multi-security market where the information signals are correlated as in their setting, the risky assets are correlated. Observing information about one asset gives information about the other assets in the economy as well.

Trading strategies

I have to limit the trading intensities of competitive and risk neutral speculators. This is because unlimited trading ends up in a price system which is fully revealing (i.e., strong-form market efficiency). Such an equilibrium is undesirable since, according to Grossman and Stiglitz (1980), it is inconsistent with acquisition of costly information. I follow Kyle (1985a) and limit the speculators' net position in the risky assets by assuming that they do not act as price and information takers. Instead they try to manipulate the information content of the equilibrium order flow by holding back their quantum relative to the competitive case such that the transaction price reveals the amount of information that suits them best in terms of expected profit. If the speculators were risk averse as in chapter 7, they would limit their trading even more.

This implies that market professional $n \in \{1, 2, ..., N\}$ at time t_{-2} wishes to choose a trading strategy that maximize his expected profit given available information and price manipulative behavior. Thus, his portfolio selection problem is to

$$\text{(2.11)} \qquad \underset{\tilde{\theta}_n}{\text{Max}} \; E\left[\tilde{\theta}_n \left(\tilde{x} - R\,\tilde{S}\right) \mid \tilde{y}_n, \tilde{y}^* = y^*\right],$$

where E[|] is the conditional expectation, θ_n is the optimal trading strategy of the market professional, and S is the equilibrium price of security k set by the market makers at time t.

Symmetrically, corporate insider m $\in$ {1, 2, ..., M} has a similar portfolio selection problem and therefore wishes to maximize

$$\text{(2.12)} \qquad \underset{\tilde{\Delta}_m}{\text{Max}} \; E\left[\tilde{\Delta}_m \left(\tilde{x} - R\,\tilde{S}\right) \mid \tilde{y}, \tilde{y}^* = y^*\right],$$

where Δ_m is the optimal trading strategy based on information available to the corporate insider prior to trading at time t.

Unlike in the rational expectations literature (see, e.g., Grossman and Stiglitz (1980)), the informed speculators do not condition on the transaction price because at the time when they determine their orders, they cannot observe or foresee the price. I condition on y* although the signal is public and could therefore be omitted along with other public information. This is because it is useful to explicitly remind the reader that there is a public disclosure. As we shall see, the public disclosure is important when the market determines its pre-trade estimates of the expectation and the variance of the future value of security k. Foster and Viswanathan (1991) develop a Kyle-type of model where public information explicitly affects the trading volume and price volatility.

In addition to the privately informed speculators, there are at time t uninformed noise or liquidity traders present in the securities market. These traders come to the market without any information, for reasons not part of this model (e.g., hedging, raise cash, reinvest dividends, or they may just chase trends), and take whatever prices the market hands them. Despite the fact that the trades of liquidity traders are not modeled explicitly, they play a crucial role to financial markets; see, e.g., Black (1986), Shleifer and Summers (1990), and Bikhchandani, Hirshleifer, and Welch (1992) for a general discussion around there issues.

I assume there exist two types of liquidity traders as in Admati and Pfleiderer (1988) and Subrahmanyam (1991): The non-discretionary liquidity traders are constrained to trade a random number of shares in one or several of the securities at one or several future auctions, whereas the discretionary liquidity traders are acting strategically, and therefore compose a portfolio of trades to minimize expected trading costs over time. The total liquidity trading in security k at time t is a random variable

$$\tilde{u} \sim N(0, \sigma), \tag{2.13}$$

where

$$\sigma = \sigma_0 + \sum_{d=1}^{D} \sigma_d. \tag{2.14}$$

This means that σ is an endogenous variable depending on where the discretionary liquidity traders cluster. The mean is normalized to zero without loss of generality. The first term is the trading by the ocean of non-discretionary liquidity traders, and the last term measures the trading by the D discretionary liquidity traders who at time t choose to trade in security k. Thus, this variance increases with the number of discretionary liquidity traders who are finding it optimal to trade in this security.

Generally, there are at least three motives for trading; the motive for risk sharing, the information motive, and finally the liquidity motive. The two last motives are present throughout the dissertation, and the first is introduced in chapter 8 by replacing the liquidity traders by hedgers as in Spiegel and Subrahmanyam (1992). Admati and Pfleiderer (1991) analyze the possibility that some liquidity traders preannounce the size of their orders.

The uninformed liquidity traders submit their demand together with the demand from the informed speculators to Q risk neutral and competitive market makers who are dealing in security k at time t. The market makers set the equilibrium price according to the price rule (this is the equilibrium condition in the dealership market):

$$(2.15) \qquad E\left[\tilde{z}_q\left(R\tilde{S} - \tilde{x}\right) \mid \sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m + \tilde{u},\ \tilde{y}^* = y^*\right] = 0,$$

where $z_q = z / Q$ is the part of the net order flow in security k at time t handled by market maker $q \in \{1, 2, ..., Q\}$. The total order flow $z = \Sigma z_q$. Since the market makers are competitive, they are forced to set the price so as to make zero expected profit; see below for further comments.

I assume that the market makers do not have any special information. It is, of course, more realistic, as in Gennotte and Leland (1990), Lindsey (1990), Foster and George (1992), and Leach and Madhavan (1992), to assume that the intermediaries have (or may acquire) superior information about the condition of the market (e.g., the amount of liquidity trading). Hughson and Bernhardt (1990) present a Kyle-type of model where the incoming orders are cleared one-by-one; see also Glosten and Milgrom (1985), Glosten (1989), and Admati and Pfleiderer (1989).

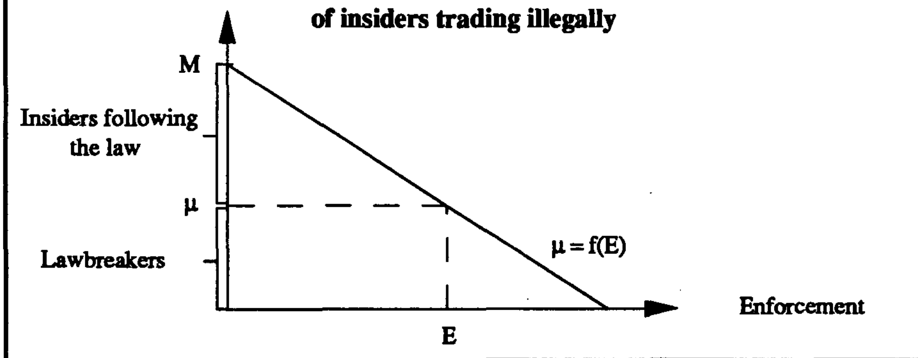
Regulation

I assume the presence of a regulatory agency (such as the Securities and Exchange Commission in the USA) that enforces the securities market law; see chapter 5 for a discussion of these issues. The regulators can prohibit insider trading or they can allow it. I define the regulatory scheme

$$(2.16) \qquad L = \begin{cases} A & \text{if insider trading is allowed, and} \\ B & \text{if insider trading is prohibited.} \end{cases}$$

If the law allows insider trading there are N market professionals and M corporate insiders trading on non-public information in the securities market. On the other hand, if the law is changed so that it prohibits insider trading there are still N market professionals, but the supply of corporate insiders decreases from M to μ where $M \geq \mu \geq 0$. Figure 2.2 illustrates.

FIGURE 2.2 Enforcement and the number of insiders trading illegally



The number of corporate insiders trading illegally depends on E the enforcement of the law by the enforcement agency.

I assume that the trading behavior of insiders does not change when they are trading illegally. It may, however, be more realistic to assume that the corporate insiders who trade illegally restrict their traded quanta for the reason that they are doing something illegal. If the insiders are allowed to trade, this may also influence the supply of market professionals, see section 3.6 or Fishman and Hagerty (1992). Thus, I allow illegal trading as detecting illegally trading insiders may be a hard task. I extend in section 5.4 - 5.5 to a corresponding market where the number of illegally trading insiders is determined as part of the equilibrium, until then μ is given exogenously.

Market clearing

I have assumed that there exist Q dealers or market makers. Their duty is to clear and stabilize the securities market and set the transaction price. All the market makers observe the arriving order flow, but they cannot distinguish the orders coming from informed speculators from the orders coming from noise traders. This means that the market makers face a price discrimination problem or what I choose to call an adverse selection problem to the pricing of securities.

In a market with perfect competition or alternatively Bertrand price competition among a limited number of risk neutral market makers, the intermediaries, in this case the market makers, do not expect to earn any economic rent (see (2.15)). It is easy to show that this condition of semi-strong market efficiency leads to a price functional

$$\tilde{S} = \frac{1}{R} E\left[\tilde{x} \mid \sum_{n=1}^{N} \tilde{\theta}_n + \sum_{m=1}^{M} \tilde{\Delta}_m + \tilde{u},\ \tilde{y}^* = y^*\right], \tag{2.17}$$

or equivalently (see footnote 7)

$$\tilde{S} = \frac{1}{R}\left[E[\tilde{x} \mid \tilde{y}^* = y^*] + \lambda\left(\sum_{n=1}^{N} \tilde{\theta}_n + \sum_{m=1}^{M} \tilde{\Delta}_m + \tilde{u}\right)\right], \tag{2.18}$$

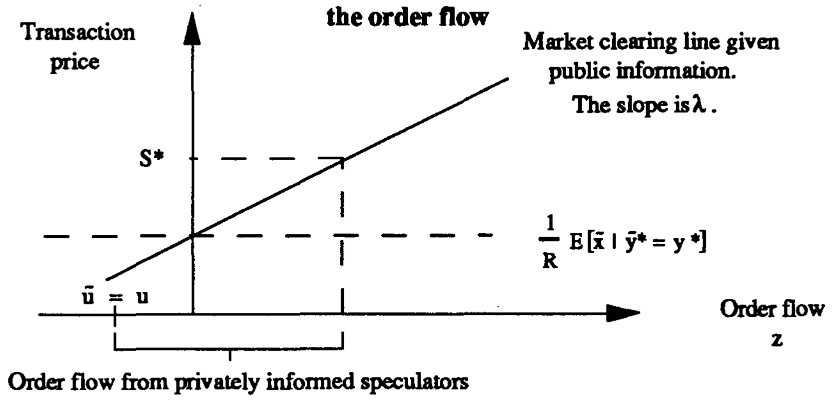
in which

$$\lambda = \frac{\operatorname{cov}\left(\tilde{x},\ \sum_{n=1}^{N} \tilde{\theta}_n + \sum_{m=1}^{M} \tilde{\Delta}_m + \tilde{u} \mid \tilde{y}^* = y^*\right)}{\operatorname{var}\left(\sum_{n=1}^{N} \tilde{\theta}_n + \sum_{m=1}^{M} \tilde{\Delta}_m + \tilde{u} \mid \tilde{y}^* = y^*\right)}, \tag{2.19}$$

where cov(, |) and var(|) are the conditional covariance and variance respectively. The first term in (2.18) is the price given publicly available information before the orders are executed at time t. I therefore call it the market price before trading. Hence, if the market makers do not observe any orders from the traders, the price at time t equals the present value of the liquidating dividend given public information. The second term is an adjustment based on the information that market makers learn by observing the net order flow (or equivalently the market price).

The price sensitivity reflects the change in the market price caused by a unit change in the order flow. If, for instance, the market makers observe a positive net order flow, they adjust the price upwards. Figure 2.3 illustrates the process.

FIGURE 2.3 Price rule as a function of the order flow



The liquidity traders are selling the amount u of the speculative asset, and the speculators are buying $\Sigma\,\theta_n$ + $\Sigma\,\Delta_m$ where $\Sigma\,\theta_n + \Sigma\,\Delta_m > |\,u\,|$. The positive net order flow indicates that the market price before trading is too low, and at time t the market makers therefore raise the transaction price to S*.

2.3 EQUILIBRIUM

A perfect Bayesian stock market equilibrium is a set of trading strategies (θ_{nkt}, Δ_{mkt}, u_{dkt}) and an equilibrium price system S_{kt} where (i) the informed speculators maximize expected profit, and (ii) the price is set to satisfy semi-strong market efficiency.

Lemma 2.1: *Suppose L = A, then there exists a unique, linear pooling of orders equilibrium [(θ_{nkt}, Δ_{mkt}, u_{dkt}); S_{kt}] for firm k ∈ {1, 2, ..., K_t} at time t ∈ {0, 1, ..., T_k-1} where the trading strategy of market professional n ∈ {1, 2, ..., N} and corporate insider m ∈ {1, 2, ..., M} are*

(3.1) $$\tilde{\theta}_n = \beta\left(\tilde{y}_n - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \textit{ and}$$

(3.2) $$\tilde{\Delta}_m = B\left(\tilde{y} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right).$$

The trading intensities are

(3.3) $$\beta = \sqrt{\frac{\sigma}{N\,(\Gamma + \varepsilon) + M\,(\Gamma + \eta)\,\alpha^2}},\ \textit{and}$$

(3.4) $$B = \alpha\,\beta,$$

where

(3.5) $$\Gamma = \frac{\delta\,\gamma}{\delta + \gamma},\ \textit{and}$$

(3.6) $$\alpha = \frac{\Gamma + 2\,\varepsilon}{\Gamma + (M + 1)\,\eta}.$$

The equilibrium price determined partially by market maker $q \in \{1, 2, \ldots, Q\}$ is

(3.7) $$\tilde{S} = \frac{1}{R}\left[E[\tilde{x} \mid \tilde{y}^* = y^*] + \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m + \tilde{u}\right)\right],$$

where the price sensitivity is

(3.8) $$\lambda = \frac{\Gamma}{N\Gamma + (M + 1)\,(\Gamma + \eta)\,\alpha}\sqrt{\frac{N\,(\Gamma + \varepsilon) + M\,(\Gamma + \eta)\,\alpha^2}{\sigma}}.$$

Proof: See appendix A (or let $\iota \rightarrow \infty$ in lemma 6.1).

Lemma 2.1 extends the trading model developed by Kyle (1984, 1985a) to the case with different quality information among privately informed speculators. Fishman and Hagerty (1992) were, as far as I know, the first to do this extension of Kyle's model in a one period, two asset framework.[3] I generalize Fishman and Hagerty's extension to the case with several insiders who are able to trade in a multi-period, multi-security market. As we shall see, my simple generalization has several interesting new features discussed in chapters 3 - 4, in which I focus on the properties of the stock market equilibrium, the welfare effects of participants, and on the stock

[3] See their lemma 1, page 108.

market regulation.

Brief remarks on later extensions

In lemma 5.1, I extend lemma 2.1 to a market where the corporate insiders are supplying as part of the equilibrium a positive expected effort. Lemma 5.4 extends lemma 5.1 to the corresponding quotation equilibrium where the market makers are expected to earn a positive amount of money to cover the cost of operating the market. In lemma 6.1, the equilibrium given by lemma 2.1 is extended further so that the corporate insiders may randomize the total supply of effort to generate superior internal information; see also lemma 2.2 below. Lemma 7.1 extends to the case where all the participants (including the market makers) are risk averse, and in lemma 8.1, the semi-rational liquidity traders are replaced by rational hedgers.

2.4 EQUILIBRIUM WHEN N = 0

The market professionals are rational, and do not enter the securities market if the cost of acquiring private information is higher than the expected profit from trading on this information. Expected profit of professionals tends to fall if the number of corporate insiders increases due to increasing competition (see sections 3.6 and 4.2 - 4.3). This indicates that an increase in the number of corporate insiders may sometimes squeeze the market professionals out of the market.

Corollary 2.1: *Suppose $L = A$, then there exists a unique, linear stock market equilibrium $[(\theta_{nkt}, \Delta_{mkt}, u_{dkt}); S_{kt} : k \in \{1, 2, ..., K_t\}, t \in \{0, 1, ..., T_k\text{-}1\}]$ where the market professionals are in zero supply. The allocation functions are*

(4.1) $$\lim_{N\to 0} \tilde{\theta}_n = \lim_{N\to 0} \beta(N) \left(\tilde{y}_n - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \textit{ and}$$

(4.2) $$\tilde{\Delta}_m = B \left(\tilde{y} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right),$$

where the trading intensities of market professional $n \in \{\emptyset\}$ and corporate insider $m \in \{1, 2, ..., M\}$ are

(4.3) $$\lim_{N \to 0} \beta(N) = \frac{1}{\alpha}\sqrt{\frac{\sigma}{M(\Gamma + \eta)}}, \text{ and}$$

(4.4) $$B = \sqrt{\frac{\sigma}{M(\Gamma + \eta)}}.$$

The price functional

(4.5) $$\tilde{S} = \frac{1}{R}\left[E[\tilde{x} \mid \tilde{y}^* = y^*] + \lambda\left(\sum_{m=1}^{M}\tilde{\Delta}_m + \tilde{u}\right)\right],$$

where the price sensitivity

(4.6) $$\lambda = \frac{\Gamma}{M+1}\sqrt{\frac{M}{(\Gamma + \eta)\sigma}}.$$

Proof: Set N = 0 in lemma 2.1. Q.E.D.

If R = M = 1 and $\eta = 0$, corollary 2.1 equals the trading model in Kyle (1985a), and if R = 1, lemma 1 in Admati and Pfleiderer (1988).[4] These are all models where the privately informed traders observe common information.

We observe that $\beta(N = 0) > \beta(N > 0)$ because the equilibrium is continuous (and thus ignoring the integer problem) which means that it is possible to increase the market power of market professionals by decreasing their supply from let say one to zero (see section 3.2).

[4] See Kyle (1985a), page 1319 and Admati and Pfleiderer (1988), page 10; see also Caballé (1990), page 7.

2.5 EQUILIBRIA WHERE INSIDER TRADING IS FORBIDDEN

If insider trading is prohibited, some of the corporate insiders may choose to break the securities market law. This is because there may be significant costs of control, implying that the enforcement of the law is not complete.

Corollary 2.2: If $L = B$, the equilibrium is given by lemma 2.1 where μ replaces M.

This is because I have assumed that it is impossible to identify and punish the traders trading illegally even if rational participants know they are present; see chapter 5 for further elaboration. Corollary 2.3 is a special case of lemma 2.1, and gives the stock market equilibrium when insider trading is effectively forbidden. That is, $\mu = 0$.

Corollary 2.3: Suppose $L = B$ and $\mu = 0$, then there exists a unique, linear securities market equilibrium $[(\theta_{nkt}, \Delta_{mkt}, u_{dkt}); S_{kt} : k \in \{1, 2, ..., K_t\}, t \in \{0, 1, ..., T_k\text{-}1\}]$ where insider trading is effectively forbidden by a law governing the securities market. The allocation functions are

(5.1)
$$\tilde{\theta}_n = \beta\left(\tilde{y}_n - \mathrm{E}[\tilde{x} \mid \tilde{y}^* = y^*]\right), \textit{ and}$$

(5.2)
$$\lim_{\mu \to 0} \tilde{\Delta}_m(\mu) = \lim_{\mu \to 0} \beta(\mu)\ \left(\tilde{y} - \mathrm{E}[\tilde{x} \mid \tilde{y}^* = y^*]\right),$$

where the trading intensities of the market professionals $n \in \{1, 2, ..., N\}$ and corporate insider $m \in \{\emptyset\}$ are

(5.3)
$$\beta = \sqrt{\frac{\sigma}{\mathrm{N}\,(\Gamma + \varepsilon)}}, \textit{ and}$$

(5.4)
$$\lim_{\mu \to 0} \mathrm{B}(\mu) = \frac{1}{\alpha`} \sqrt{\frac{\sigma}{\mathrm{N}\,(\Gamma + \varepsilon)}}.$$

The price functional

$$(5.5) \qquad \tilde{S} = \frac{1}{R}\left[E[\tilde{x} \mid \tilde{y}^* = y^*] + \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \tilde{u}\right)\right],$$

where the price sensitivity

$$(5.6) \qquad \lambda = \frac{\Gamma}{(N+1)\Gamma + 2\varepsilon}\sqrt{\frac{N(\Gamma + \varepsilon)}{\sigma}}.$$

Proof: I use corollary 2.2 and then set $\mu = 0$ in lemma 2.1. Notice that $\alpha` = \alpha(\mu = 0) > \alpha(\mu > 0)$, but the empty set of corporate insiders has no effect on the order flow and pricing. Q.E.D.

When R and Γ are normalized to unity, corollary 2.2 equals the model with diverse information among the informed speculators in Admati and Pfleiderer (1988), and when R = 1, the trading model with perfectly competitive market makers in Kyle (1984).[5]

2.6 TRADING ON UNCORRELATED INFORMATION

The corporate insiders are now assumed to observe information that is not correlated with the information observed by the market professionals. This is easily done by splitting the future value of the securities in two independent terms. Then I let each type of informed speculators observe a signal correlated with one of the terms as in Subrahmanyam (1991).

New assumptions

If not expressed otherwise, I draw on the assumptions specified in section 2.2 (see also section 6.2). The value of security $k \in \{1, 2, ..., K_t\}$ at time $t+1 \in \{0, 1, ..., T_k-1\}$ is now assumed to have two independent

[5] See lemma 3, page 22 in Admati and Pfleiderer's article and pages 56 - 60 in Kyle's article; see also Caballé (1990), page 6.

components. One component is unique for security k and reflects security-specific events such as the effort and the investment decisions of the corporate employees during the period from t to t+1. The other component depends, for instance, on a common term present in the value of all the securities. It thereby reflects general economic events influencing all the securities listed on the stock market exchange. In this way, the future value of security k is

$$\tilde{x} + \tilde{e}, \tag{6.1}$$

where e is the security-specific or idiosyncratic component and x is the systematic component influencing security k's value at time t+1. The random business fluctuations are given by (2.2), and the security-specific component

$$\tilde{e} \sim N(m_e, \phi). \tag{6.2}$$

In this section, the security-specific component is given exogenously, but in section 6.4, it is determined as part of the equilibrium.

Prior to trading at time t, there is a public signal (in addition to y*) correlated with the security-specific component. That is,

$$\tilde{y}^{*} = \tilde{e} + \tilde{j}, \tag{6.3}$$

where the noise term

$$\tilde{j} \sim N(0, \varphi). \tag{6.4}$$

This signal is used to update the prior expectations given by (6.2). One effect of public information is that it reduces the risk associated with net value of the security-specific events from ϕ to Φ where Φ is given by (6.13).

In this section, the corporate insiders observe only common private information correlated with the change in the security-specific component from time t time t+1 (thus, $\eta \to \infty$, leaving signal y without information content). This means that corporate insider $m \in \{1, 2, ..., M\}$ instead of observing the signal y given by (2.6) observes a signal

$$\tilde{Y} = \tilde{e} + \tilde{i}, \tag{6.5}$$

where

$$\tilde{i} \sim N(0, \iota). \tag{6.6}$$

This signal is assumed to be less noisy than the signal $y\bullet$ observed by all the participants in the securities market. All error terms are uncorrelated.

As outlined in section 2.2, the market professionals observe one signal each correlated with the net value of the random business fluctuations. Their signal y_n is given by (2.8). Notice that the two types of informed speculators observe uncorrelated information because

$$\operatorname{cov}\left(\tilde{Y}, \tilde{y}_n \mid \tilde{y}^* = y^*, \tilde{y}\bullet = y\bullet\right) = 0. \tag{6.7}$$

This assumption separates the two types of information, and gives the corporate insiders a greater market power than in lemma 2.1 as they have not to compete directly with the market professionals. However, the two types of informed speculators compete indirectly because they both may increase the adverse selection problem faced by the price setting market makers.

Equilibrium

This subsection presents a unique equilibrium in an exchange market with two independent sources of private information as described above.

Lemma 2.2: *Suppose L = A, then there exists a unique, linear pooling of orders equilibrium [(θ_{nkt}, Δ_{mkt},*

u_{dkt}); S_{kt}] for firm $k \in \{1, 2, ..., K_t\}$ at time $t \in \{0, 1, ..., T_k\text{-}1\}$ where the trading strategy of market professional $n \in \{1, 2, ..., N\}$ and corporate insider $m \in \{1, 2, ..., M\}$ are

$$(6.8) \qquad \tilde{\theta}_n = \beta\left(\tilde{y}_n - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \textit{ and}$$

$$(6.9) \qquad \tilde{\Delta}_m = b\left(\tilde{Y} - E[\tilde{e} \mid \tilde{y}_\bullet = y_\bullet]\right),$$

respectively. The trading intensities are

$$(6.10) \qquad \beta = \sqrt{\frac{\sigma}{N(\Gamma + \varepsilon) + M(\Phi + \iota)a^2}}, \textit{ and}$$

$$(6.11) \qquad b = a\beta,$$

where

$$(6.12) \qquad a = \frac{[(N + 1)\Gamma + 2\varepsilon]\Phi}{(M + 1)(\Phi + \iota)\Gamma}, \textit{ and}$$

$$(6.13) \qquad \Phi = \frac{\phi\varphi}{\phi + \varphi}.$$

The market price of security k at time t

$$(6.14) \qquad \tilde{S} = \frac{1}{R}\left[E[\tilde{x} + \tilde{e} \mid \tilde{y}^* = y^*, \tilde{y}_\bullet = y_\bullet] + \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m + \tilde{u}\right)\right],$$

is partially set by the risk neutral and competitive market maker $q \in \{1, 2, ..., Q\}$ by quoting the price sensitivity

$$(6.15) \qquad \lambda = \frac{\Gamma}{(N + 1)\Gamma + 2\varepsilon}\sqrt{\frac{N(\Gamma + \varepsilon) + M(\Phi + \iota)a^2}{\sigma}}.$$

Proof: See appendix B (or let $\eta \to \infty$ in lemma 6.1).

Lemma 2.2 extends the trading model of Subrahmanyam (1991) to a setting where the systematic factor informed traders trade intertemporalily on diverse private information.[6] In addition, this lemma also extends the trading models of Admati and Pfleiderer (1988) to a world with several risky assets and trading on two independent sources of information.

Extensions

In lemma 6.1, I extend lemma 2.2 to a corresponding securities market where the corporate insiders also trade on information about random business fluctuations (thus, $\eta < \infty$, making y valuable). This equilibrium is used to analyze insider trading as an incentive mechanism by interpreting the term e in (6.1) as managerial effort which in lemmas 6.2 - 6.4 is determined as part of the equilibrium.

Equilibria when N = 0 or L = B

If N = 0 because the cost of acquiring private information is higher than the expected profit generated from this information, lemma 2.2 is given by corollary 6.1 where Y replaces y, b replaces β, **a** replaces α, Φ replaces Γ, and ι replaces η.

Corollary 2.4: *If L = B, then μ replaces M in lemma 2.2.*

If $\mu = 0$, then the equilibrium is given by corollary 6.3 where Y replaces y, b replaces β, and **a** replaces α. The reason for this simple transformation is that I have assumed that the corporate insiders do not change behavior when L shifts from A to B. This is because they are perfectly camouflaged by the liquidity traders and the

[6] See his lemma 3 on page 28 for a one period model where both traders observe common private information. Subrahmanyam also allows trading in a basket of securities, and uses the model to study trading in stock index futures.

always legally trading market professionals.

2.7 BROKER - AUCTION MARKET APPROACH

Equilibrium prices are usually determined by imposing strict (Walrasian) market clearing among the various types of traders; see, e.g., Grossman (1989). This means that in most financial market models there is no need to demonstrate explicitly how the prices are determined as part of the equilibrium (see also models with homogeneous information like the one presented by Duffie (1992) where prices are determined by no arbitrage opportunities). Consequently there are no dealers or market makers present in these models. This is in contrast to what we observe in many real financial markets. Nonetheless, in most financial market models there are usually broker - arbitrageurs who provide immediacy (that is the ability to trade now rather than wait for a trader to take the opposite position as is the case in search markets) and tend to trade away profit based on public information.

In the real world, there exist two types of securities markets called broker and dealership markets where the differences are as follows; see Schwartz (1988), especially, pages 18 - 19, Pagano and Röell (1992), and Yavas (1992):

- A broker - auction (or agency) market is a trading system where public orders go to the exchange which matches them with other public orders. The traders trade with a broker (who is the trader`s agent) who trades with a brokers` broker or a matchmaker. Finally, the brokers` broker matches the orders at the exchange. An example of a pure broker market is the Tokyo Stock Exchange where the order clerks (called Saitori) are not allowed to participate in the trade by holding large position on their own accounts. They only maintain the limit order book and monitor trading.
- A (pure) dealership market is a trading system where public traders do not trade directly with each other, but trade with a dealer or a market maker who serves as intermediary. An example of a dealership market is the over-the-counter market in the United States. The traders trade through a broker, who buys or sells to a dealer.

Most exchanges in Europe are broker markets, and most of the dealership markets are not pure dealership markets. In the normal course of business the orders in a dealership market are matched between the various types of traders. But if there are order imbalances, the dealers take the opposite position. Most of the stock exchanges in the United States are what we might call dealer/broker markets. London Stock Exchange is the leading dealer/broker market in Europe; see, for instance, Pagano and Röell (1990) for a discussion on the trading systems in Europe. The trend on several exchanges, for example at Oslo Stock Exchange, is to allow market making.

At the New York Stock Exchange there are specialists, who have functions both as market makers and brokers, and member firms (brokerage houses) which compete with the specialists. The specialist operates as a dealer when he buys or sells from his own inventory of stocks, and as a broker when he handles the limit order book. The limit order book competes directly with the quotes of the specialist. For example, a limit order to buy specifies a particular quantity to be bought at a predetermined price or lower. A market order to buy, on the other hand, specifies that the trader is willing to buy a particular quantity of shares at the best price in the market. This indicates that the quoted prices (bids or asks) can be the specialist's own and not the quotes of other traders as is always the case in a broker market. The specialists as market makers also have an obligation to maintain a fair and orderly market. Lindsey and Schaede (1992) make an interesting comparison of the trading systems at the world's two largest stock markets, the TSE and the NYSE.

I will show that our securities market model can be interpreted both as a broker market and as a dealership market. That is, the price setting market makers in a dealership market can also be interpreted as arbitrageurs in a broker market, assuring that trading on public information yields zero profit. This does not mean, of course, that dealership markets are identical to broker markets with respect to the pricing of securities in general. The difference between broker - auction markets and dealership markets appears if there for some reason are too few arbitrageurs. In this way, the dealer can be seen as a provider of insurance against execution risk. That is the risk of finding few or no counterparts to trade, see, e.g., Pagano and Röell (1990) for a discussion of these matters.

Assumptions

I assume there exist A risk neutral arbitrageurs who have rational expectations. Rational expectations means that the arbitrageurs use the equilibrium price as a source of knowledge when determining their optimal trading strategies. The portfolio selection problem of arbitrageur $a \in \{1, 2, ..., A\}$, trading in security $k \in \{1, 2, ..., K_t\}$ at time $t \in \{0, 1, ..., T_k-1\}$, is to maximize expected profit given the price information and strategic behavior.

$$\text{(7.1)} \qquad \underset{\tilde{\Lambda}_a}{\text{Max}}\ E\left[\tilde{\Lambda}_a \left(\tilde{x} - R\,\tilde{S}\right) \mid \tilde{S}, \tilde{y}^* = y^*\right],$$

where Λ_a is the trading strategy. Now I make an important assumption that the arbitrageur follows a linear (negative) feedback strategy

$$\text{(7.2)} \qquad \tilde{\Lambda}_a = -\psi_a \left(R\,\tilde{S} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right),$$

where ψ_a is the trading intensity on public price information. Hence, the arbitrageurs buy when the price falls unexpectedly, and sell when the market price rises unexpectedly. This is often referred to as market timing. If there are no arbitrageurs in the auction market, it becomes almost a search market characterized by a low supply of immediacy (see Yavas (1992), pages 35 - 38). That is a securities market where a buyer normally has to wait for a seller to arrive before he can transact.

Market clearing

Since I assume a broker market, the equilibrium price is produced by strict "market clearing" among the traders at the auction at time t:

$$\text{(7.3)} \qquad \sum_{a=1}^{A}\tilde{\Lambda}_a + \sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Lambda}_m + \tilde{u} = 0.$$

The first term is the demand from the arbitrageurs, the second and third are the demands from the privately informed speculators, and the last term is the demand from the liquidity traders. The volume of the arbitrageurs (or market makers), for instance, can also be interpreted as the supply of the risky asset. In a market where the informed speculators learn information from equilibrium prices, they will have a stabilizing effect much alike the one performed by the arbitrageurs.

Equilibrium

It is straightforward to show that the equilibrium price of security k at time t must be linear in the net order flow from the two last types of traders (see Kyle (1984)):

$$\tilde{S} = \frac{1}{R}\left[E[\tilde{x} \mid \tilde{y}^* = y^*] + \frac{1}{\sum_{a=1}^{A} \psi_a}\left(\sum_{n=1}^{N} \tilde{\theta}_n + \sum_{m=1}^{M} \tilde{\Delta}_m + \tilde{u}\right)\right]. \tag{7.4}$$

Define

$$\lambda^* \equiv \frac{1}{\sum_{a=1}^{A} \psi_a}, \tag{7.5}$$

where this parameter is interpreted as the sensitivity of the market price to changes in the order flow from the privately informed speculators and the noise traders. The price sensitivity is a regression coefficient and must therefore satisfy (3.8) above, at least when A approaches infinity.

Broker vs dealership markets

I summarize the difference between broker and dealership market assuming that the supply of immediacy is identical in the two markets:

Proposition 2.1: *A broker market with a limited number of risk neutral and competitive arbitrageurs, whose trading strategies are given by (7.2), produces the same transaction price as a corresponding dealership market where the price is set by competitive and risk neutral market makers.*

Proof: If (7.5) equals (2.19), the proposition holds because the price function given by (7.4) is identical to (3.7). One way of proving this under the specified conditions is by first assuming that the broker - arbitrageurs act strategically. Kyle (1984) has shown (see his equations (21) and (22) on page 58) that the price sensitivity in such a market is

$$(7.6) \qquad \lambda^{*} = \frac{1}{A\,\psi} = \frac{A - 2}{A - 1}\,\lambda,$$

see also the proof of lemma 8.1 where this price sensitivity appears as a special case. It follows that $\lambda^{*}(A \rightarrow \infty) = \lambda$ where λ is given by (2.19) or (3.8). Finally, if a limited number of risk neutral arbitrageurs act competitively, they act as if they were infinitely many, and the component reflecting market power (i.e., (A - 2) / (A - 1)) will be one for all A. Q.E.D.

When I later refer to market makers in a dealership market setting, I could alternatively refer to arbitrageurs in a broker market setting.

2.8 SOME EXTENSIONS

This section discusses some important extensions which are considered to be beyond the scope of this dissertations. Chapters 5 - 8 extend the lemmas derived in this chapter to take into account, for instance, production, disclosure, risk averse traders, risk averse pricing, hedging, and market power in the arbitrage - dealership market, but non of these chapters take into account long-lived information or continuous trading.

Long-lived information

In lemma 2.1 there are T_k discrete times where the securities in firm k are traded sequentially. But information observed prior to trading at time t is only useful at the next auction and not at any later auctions. This is because the innovation **d** and thereby the value of the security become public information at time t+1 (see (2.2)). Prior to time t+1 there is a new signal and so on. The approach with short-lived information goes back to Admati and Pfleiderer (1988). Alternatively, the informed speculators could observe private information before time 0 and then trade sequentially at the auctions from 0 to T_k-1. New information which arrives before time 1 could be used at the auctions from 1 to T_k-1, and so on. Then if the value of the firm becomes public knowledge at the horizon, the problem of informed speculators must include considerations about whether to trade now or wait. Thus, it may be optimal to trade less now and store information for later periods. Kyle (1985a), Foster and Viswanathan (1990), and Holden and Subrahmanyam (1992) analyze the effect of long-lived information. Kyle's insider observe only one signal and may trade sequentially on his superior information (see his section 3). He finds that information is incorporated gradually into the price because the insider trades in a smooth manner and therefore holds a smooth stock of inside information. Holden and Subrahmanyam allow multiple privately informed agents who all observe information of the same quality. They show that competition forces their common private information to be revealed very rapidly (see also Dutta and Madhavan (1991)). Finally, Foster and Viswanathan combine discrete and continuous trading and thereby taking into account that the exchange is closed over night. During the day, trading happens continuously. For instance, they show that when private information is to be revealed at a later date, the informed individual must transact more intensely, causing the private information to be released more quickly.

Continuous trading

I have assumed that trading takes place sequentially at the call auctions from 0 to T_k-1 which means that lemma 2.1 is characterized by batch trading. In the most important financial markets, though, trading happens continuously from the exchange opens until it closes. Kyle (1985ab) analyzes continuous insider trading (see also Back (1992)). He finds that the insider trades gradually over time and increases his expected profit relative to the discrete case with sequential auctions. The transaction price becomes more and more informative and converges towards the liquidating value at the horizon. The incentives to acquire private information do not at any time disappear.

2.9 SHORT SUMMARY OF THE RESEARCH APPROACH

I have presented a simple securities market model suitable for analyzing various effects of insider trading regulations in financial markets. This is because it takes into account may elements observed on the world's largest stock exchanges which are the NYSE, the TSE, and the LSE. Chapters 3 - 4 use lemma 2.1 to analyze the many effects of insider trading and insider trading regulations in financial markets. Later chapters extend the outlined framework to capture other elements relevant for the insider trading debate.

APPENDICES

This section contains the formal proofs of lemmas 2.1 - 2.2.

Appendix A Proof of lemma 2.1

The decision problem of insider $m \in \{1, 2, \dots M\}$ is to choose the trading strategy Δ_m which maximizes his expected profit given the information generated by observing the signal y. This problem is given by (2.12) or equivalently

$$\text{(A1)} \qquad \underset{\tilde{\Delta}_m}{\text{Max}}\ \tilde{\Delta}_m \left\{E[\tilde{x} \mid \tilde{y}, \tilde{y}^* = y^*] - E\left[R\,\tilde{S} \mid \tilde{y}, \tilde{y}^* = y^*\right]\right\},$$

where Δ_m is the insider's trading strategy and therefore his decision variable. I insert the price function given by (2.18) and get

$$\text{(A2)} \qquad \underset{\tilde{\Delta}_m}{\text{Max}}\ \tilde{\Delta}_m \left\{E[\tilde{x} \mid \tilde{y}, \tilde{y}^* = y^*] - E\left[E[\tilde{x} \mid \tilde{y}^* = y^*] + \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m + \tilde{u}\right) \mid \tilde{y}, \tilde{y}^* = y^*\right]\right\},$$

or (after using that $E[u \mid y, y^*=y^*] = 0$)

$$\text{(A3)}\quad \underset{\tilde{\Delta}_m}{\mathrm{Max}}\ \tilde{\Delta}_m \left\{ E[\tilde{x} \mid \tilde{y}, \tilde{y}^* = y^*] - E[\tilde{x} \mid \tilde{y}^* = y^*] - \lambda \left(\tilde{\Delta}_m + E\left[\sum_{n=1}^{N} \tilde{\theta}_n + \sum_{m=1}^{M-1} \tilde{\Delta}_m \mid \tilde{y}, \tilde{y}^* = y^* \right] \right) \right\}.$$

The insider takes the price sensitivity and the trading strategies of other insiders and the market professionals as given. This suggests a Nash-type of equilibrium (see Fudenberg and Tirole (1991), pages 11 - 44). The first order condition is

$$\text{(A4)}\quad E[\tilde{x} \mid \tilde{y}, \tilde{y}^* = y^*] - E[\tilde{x} \mid \tilde{y}^* = y^*] - \lambda \left(2\,\tilde{\Delta}_m + E\left[\sum_{n=1}^{N} \tilde{\theta}_n + \sum_{m=1}^{M-1} \tilde{\Delta}_m \mid \tilde{y}, \tilde{y}^* = y^* \right] \right) = 0,$$

where

$$\text{(A5)}\quad E\left[\sum_{m=1}^{M-1} \tilde{\Delta}_m \mid \tilde{y}, \tilde{y}^* = y^* \right] = (M - 1)\,\tilde{\Delta}_m.$$

The second order condition is $-2\lambda < 0$ which is satisfied if $\lambda > 0$. I insert (A5) into (A4) and solve for Δ_m. The result is

$$\text{(A6)}\quad \tilde{\Delta}_m = \frac{1}{(M+1)\lambda} \left(E[\tilde{x} \mid \tilde{y}, \tilde{y}^* = y^*] - E[\tilde{x} \mid \tilde{y}^* = y^*] \right) - \frac{1}{M+1} E\left[\sum_{n=1}^{N} \tilde{\theta}_n \mid \tilde{y}, \tilde{y}^* = y^* \right],$$

where[7]

$$\text{(A7)}\quad E[\tilde{x} \mid \tilde{y}, \tilde{y}^* = y^*] = E[\tilde{x} \mid \tilde{y}^* = y^*] + \frac{\mathrm{cov}(\tilde{x}, \tilde{y} \mid \tilde{y}^* = y^*)}{\mathrm{var}(\tilde{y} \mid \tilde{y}^* = y^*)} \left(\tilde{y} - E[\tilde{y} \mid \tilde{y}^* = y^*] \right), \text{ and}$$

[7] Generally, if x and y are normally distributed variables, then (see, e.g., Goldberger (1991), chapter 7 especially page 75)

$$E[\tilde{x} \mid \tilde{y}] = E[\tilde{x}] + \frac{\mathrm{cov}(\tilde{x}, \tilde{y})}{\mathrm{var}(\tilde{y})} \left(\tilde{y} - E[\tilde{y}] \right), \text{ and } \mathrm{var}(\tilde{x} \mid \tilde{y}) = \mathrm{var}(\tilde{x}) - \frac{\mathrm{cov}^2(\tilde{x}, \tilde{y})}{\mathrm{var}(\tilde{y})}.$$

$$\text{(A8)}\quad E\left[\sum_{n=1}^{N}\tilde{\theta}_n \mid \tilde{y}, \tilde{y}^* = y^*\right] = \underbrace{E\left[\sum_{n=1}^{N}\tilde{\theta}_n \mid \tilde{y}^* = y^*\right]}_{=0} + \frac{\operatorname{cov}\left(\sum_{n=1}^{N}\tilde{\theta}_n, \tilde{y} \mid \tilde{y}^* = y^*\right)}{\operatorname{var}(\tilde{y} \mid \tilde{y}^* = y^*)}\left(\tilde{y} - E[\tilde{y} \mid \tilde{y}^* = y^*]\right).$$

I insert (A7) and (A8) into (A6) and get

$$\text{(A9)}\qquad \tilde{\Delta}_m = \frac{\operatorname{cov}(\tilde{x}, \tilde{y} \mid \tilde{y}^* = y^*) - \lambda \operatorname{cov}\left(\sum_{n=1}^{N}\tilde{\theta}_n, \tilde{y} \mid \tilde{y}^* = y^*\right)}{(M+1)\operatorname{var}(\tilde{y} \mid \tilde{y}^* = y^*)\,\lambda}\left(\tilde{y} - E[\tilde{y} \mid \tilde{y}^* = y^*]\right).$$

Note that E[y | y*=y*] = E[x | y*=y*] because E[**h** | y*=y*] = 0 which means that the trading strategy equals (3.2) where

$$\text{(A10)}\qquad B = \frac{\operatorname{cov}(\tilde{x}, \tilde{y} \mid \tilde{y}^* = y^*) - \lambda \operatorname{cov}\left(\sum_{n=1}^{N}\tilde{\theta}_n, \tilde{y} \mid \tilde{y}^* = y^*\right)}{(M+1)\operatorname{var}(\tilde{y} \mid \tilde{y}^* = y^*)\,\lambda},$$

in which

$$\text{(A11)}\qquad \operatorname{cov}(\tilde{x}, \tilde{y} \mid \tilde{y}^* = y^*) = \operatorname{cov}\left(\tilde{x}, \tilde{x} + \tilde{\mathbf{h}} \mid \tilde{y}^* = y^*\right) = \operatorname{var}(\tilde{x} \mid \tilde{y}^* = y^*) = \Gamma, \text{ and}$$

$$\text{(A12)}\qquad \operatorname{var}(\tilde{y} \mid \tilde{y}^* = y^*) = \operatorname{var}\left(\tilde{x} + \tilde{\mathbf{h}} \mid \tilde{y}^* = y^*\right) = \Gamma + \eta.$$

A rational insider anticipates the structural form of the trading strategy of the market professionals. I use (3.1) and obtain

$$\text{(A13)}\qquad \operatorname{cov}\left(\sum_{n=1}^{N}\tilde{\theta}_n, \tilde{y} \mid \tilde{y}^* = y^*\right) = \operatorname{cov}\left(N\beta\left(\tilde{y}_n - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \tilde{y} \mid \tilde{y}^* = y^*\right) = N\beta \operatorname{cov}(\tilde{y}_n, \tilde{y} \mid \tilde{y}^* = y^*) = N\beta\,\Gamma.$$

I insert (A11), (A12), and (A13) into (A10) and get

(A14)
$$B = \frac{[1 - N\beta\lambda]\Gamma}{(M + 1)(\Gamma + \eta)\lambda}.$$

As indicated by (2.11), the problem of market professional $n \in \{1, 2, ..., N\}$ is to choose the trading strategy which maximizes his expected profit given the information generated by observing the signal y_n. That is,

(A15)
$$\underset{\tilde{\theta}_n}{\mathrm{Max}}\ \tilde{\theta}_n \left\{ E\left[\tilde{x} \mid \tilde{y}_n, \tilde{y}^* = y^*\right] - E\left[R\tilde{S} \mid \tilde{y}_n, \tilde{y}^* = y^*\right] \right\}.$$

I insert the price function given by (2.18) and obtain after some straightforward simplifications

(A16)
$$\underset{\tilde{\theta}_n}{\mathrm{Max}}\ \tilde{\theta}_n \left\{ E\left[\tilde{x} \mid \tilde{y}_n, \tilde{y}^* = y^*\right] - E\left[\tilde{x} \mid \tilde{y}^* = y^*\right] - \lambda \left(\tilde{\theta}_n + E\left[\sum_{n=1}^{N-1} \tilde{\theta}_n + \sum_{m=1}^{M} \tilde{\Delta}_m \mid \tilde{y}_n, \tilde{y}^* = y^* \right] \right) \right\}.$$

The first order condition is

(A17)
$$E\left[\tilde{x} \mid \tilde{y}_n, \tilde{y}^* = y^*\right] - E\left[\tilde{x} \mid \tilde{y}^* = y^*\right] - \lambda \left(2\,\tilde{\theta}_n + E\left[\sum_{n=1}^{N-1} \tilde{\theta}_n + \sum_{m=1}^{M} \tilde{\Delta}_m \mid \tilde{y}_n, \tilde{y}^* = y^* \right] \right) = 0,$$

or

(A18)
$$\tilde{\theta}_n = \frac{1}{2\lambda} \left(E\left[\tilde{x} \mid \tilde{y}_n, \tilde{y}^* = y^*\right] - E\left[\tilde{x} \mid \tilde{y}^* = y^*\right] \right) - \frac{1}{2} E\left[\sum_{n=1}^{N-1} \tilde{\theta}_n + \sum_{m=1}^{M} \tilde{\Delta}_m \mid \tilde{y}_n, \tilde{y}^* = y^* \right].$$

If $\lambda > 0$, the second order condition $- 2\lambda < 0$ is satisfied. I use the rule for condition expectation (see footnote above) and get

(A19)
$$E\left[\tilde{x} \mid \tilde{y}_n, \tilde{y}^* = y^*\right] = E\left[\tilde{x} \mid \tilde{y}^* = y^*\right] + \frac{\mathrm{cov}(\tilde{x}, \tilde{y}_n \mid \tilde{y}^* = y^*)}{\mathrm{cov}(\tilde{y}_n \mid \tilde{y}^* = y^*)} \left(\tilde{y}_n - E\left[\tilde{y}_n \mid \tilde{y}^* = y^*\right] \right),$$

$$\text{(A20)}\ E\left[\sum_{n=1}^{N-1}\tilde{\theta}_n \mid \tilde{y}_n,\ \tilde{y}^*=y^*\right]=\underbrace{E\left[\sum_{n=1}^{N-1}\tilde{\theta}_n \mid \tilde{y}^*=y^*\right]}_{=0}+\frac{\operatorname{cov}\left(\sum_{n=1}^{N-1}\tilde{\theta}_n,\tilde{y}_n \mid \tilde{y}^*=y^*\right)}{\operatorname{cov}(\tilde{y}_n \mid \tilde{y}^*=y^*)}\left(\tilde{y}_n-E[\tilde{y}_n \mid \tilde{y}^*=y^*]\right),\ \text{and}$$

$$\text{(A21)}\ E\left[\sum_{m=1}^{M}\tilde{\Delta}_m \mid \tilde{y}_n,\ \tilde{y}^*=y^*\right]=\underbrace{E\left[\sum_{m=1}^{M}\tilde{\Delta}_m \mid \tilde{y}^*=y^*\right]}_{=0}+\frac{\operatorname{cov}\left(\sum_{m=1}^{M}\tilde{\Delta}_m,\tilde{y}_n \mid \tilde{y}^*=y^*\right)}{\operatorname{cov}(\tilde{y}_n \mid \tilde{y}^*=y^*)}\left(\tilde{y}_n-E[\tilde{y}_n \mid \tilde{y}^*=y^*]\right).$$

I insert (A19), (A20), and (A21) into (A18). The result is

$$\text{(A22)}\quad \tilde{\theta}_n = \frac{\operatorname{cov}(\tilde{x},\ \tilde{y}_n \mid \tilde{y}^*=y^*) - \lambda \operatorname{cov}\left(\sum_{n=1}^{N-1}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m,\ \tilde{y}_n \mid \tilde{y}^*=y^*\right)}{2\operatorname{cov}(\tilde{y}_n \mid \tilde{y}^*=y^*)\,\lambda}\left(\tilde{y}_n - E[\tilde{y}_n \mid \tilde{y}^*=y^*]\right).$$

Notice that $E[y_n \mid y^*=y^*] = E[x \mid y^*=y^*]$ because $E[e_n \mid y^*=y^*] = 0$. This means that the trading strategy is given by (3.1) where

$$\text{(A23)}\qquad \beta = \frac{\operatorname{cov}(\tilde{x},\ \tilde{y}_n \mid \tilde{y}^*=y^*) - \lambda \operatorname{cov}\left(\sum_{n=1}^{N-1}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m,\ \tilde{y}_n \mid \tilde{y}^*=y^*\right)}{2\operatorname{cov}(\tilde{y}_n \mid \tilde{y}^*=y^*)\,\lambda}.$$

I find that

$$\text{(A24)}\qquad \operatorname{cov}(\tilde{x},\ \tilde{y}_n \mid \tilde{y}^*=y^*) = \operatorname{cov}(\tilde{x},\ \tilde{x}+\tilde{e}_n \mid \tilde{y}^*=y^*) = \operatorname{var}(\tilde{x} \mid \tilde{y}^*=y^*) = \Gamma,$$

$$\text{(A25)}\qquad \operatorname{var}(\tilde{y}_n \mid \tilde{y}^*=y^*) = \operatorname{var}(\tilde{x}+\tilde{e}_n \mid \tilde{y}^*=y^*) = \Gamma + \varepsilon,$$

$$\text{(A26)}\qquad \operatorname{cov}\left(\sum_{n=1}^{N-1}\tilde{\theta}_n,\ \tilde{y}_n \mid \tilde{y}^*=y^*\right) = \operatorname{cov}\left((N-1)\beta\ (\tilde{y}_n - E[\tilde{x} \mid \tilde{y}^*=y^*]),\ y_n \mid \tilde{y}^*=y^*\right) =$$
$$(N-1)\beta\operatorname{cov}(\tilde{x}+\tilde{e}_n,\ \tilde{x}+\tilde{e}_n \mid \tilde{y}^*=y^*) = (N-1)\beta\,\Gamma,\ \text{and}$$

$$\text{(A27)} \qquad \operatorname{cov}\left(\sum_{m=1}^{M}\tilde{\Delta}_m,\, \tilde{y}_n \mid \tilde{y}^* = y^*\right) = \operatorname{cov}\left(MB\,\left(\tilde{y} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right),\, y_n \mid \tilde{y}^* = y^*\right) =$$

$$MB\,\operatorname{cov}\left(\tilde{x} + \tilde{h},\, \tilde{x} + \tilde{e}_n \mid \tilde{y}^* = y^*\right) = MB\Gamma.$$

The market professionals are assumed to observe diverse information which means that $\operatorname{cov}(e_n, e_n \mid y^* = y^*) = 0$ when $n \neq n$. The next step is to insert (A24) - (A27) into (A23). The result is

$$\text{(A28)} \qquad \beta = \frac{\left[1 - \lambda\left[(N - 1)\beta + MB\right]\right]\Gamma}{2\,(\Gamma + \varepsilon)\,\lambda},$$

or

$$\text{(A29)} \qquad \beta = \frac{[1 - MB\lambda\,]\,\Gamma}{[(N + 1)\,\Gamma + 2\,\varepsilon]\,\lambda}.$$

I insert (A14) and obtain

$$\text{(A30)} \qquad \beta = \frac{\Gamma}{[N\Gamma + (M + 1)\,(\Gamma + \eta)\,\alpha]\,\lambda},$$

where α is given by (3.6). The next step is to substitute this back into (A14) which gives the relationship between B and β given by (3.4). Then I use the trading strategies of market professionals and corporate insiders given by (3.1) and (3.2) to split the order flow up into its basic elements:

$$\text{(A31)} \qquad \tilde{z} = \beta\left[(N + M\alpha)\,\tilde{x} + \beta\sum_{n=1}^{N}\tilde{e}_n + M\alpha\tilde{h}\right] + \tilde{u} - \beta\,(N + M\alpha)\,E[\tilde{x} \mid \tilde{y}^* = y^*],$$

which means that

$$\text{(A32)} \qquad \operatorname{cov}(\tilde{x}, \tilde{z} \mid \tilde{y}^* = y^*) = \beta\,(N + M\alpha)\,\Gamma, \text{ and}$$

$$\text{(A33)} \qquad \operatorname{var}(\tilde{z} \mid \tilde{y}^* = y^*) = \beta^2 \left[(N + M\alpha)^2 \Gamma + N\varepsilon + M^2 \alpha^2 \eta\right] + \sigma.$$

I insert (A32) and (A33) into (2.19) and get

$$\text{(A34)} \qquad \lambda = \frac{\beta\,(N + M\alpha)\Gamma}{\beta^2 \left[(N + M\alpha)^2 \Gamma + N\varepsilon + M^2 \alpha^2 \eta\right] + \sigma}.$$

I substitute (A30) into (A34) and solve for λ. The result is given by (3.8). I then substitute (3.8) into (A30) and get (3.3). Finally, notice that (see footnote 7)

$$\text{(A35)} \qquad \Gamma = \operatorname{var}(\tilde{x} \mid \tilde{y}^* = y^*) = \operatorname{var}(\tilde{x}) - \frac{\operatorname{cov}^2(\tilde{x}, \tilde{y}^*)}{\operatorname{var}(\tilde{y}^*)} = \frac{\delta\gamma}{\delta + \gamma},$$

which equals (3.5). This completes the proof of lemma 2.1.

Appendix B Proof of lemma 2.2

This proof is a special case of the proof of lemma 6.1 given in appendix 6.A. It is very close to the proof given in the previous appendix. Market professional $n \in \{1, 2, ..., N\}$ wants to find a trading strategy which is a solution to the portfolio selection problem:

$$\text{(B1)} \qquad \underset{\tilde{\theta}_n}{\operatorname{Max}}\ \tilde{\theta}_n \left\{E[\tilde{x} \mid \tilde{y}_n, I] - E[R\tilde{S} \mid \tilde{y}_n, I]\right\},$$

where I is an information structure reflecting publicly available information (thus, $I = \{y^*=y^*, y_\bullet=y_\bullet, ...\}$). The proof mimics the solution procedure given by (A16) - (A30) excepts for the fact that y now is non-informative (because $\eta \rightarrow \infty$ by assumption). In this way, the trading strategy of the market professionals is given by (6.8) where the trading intensity

$$\text{(B2)} \qquad \beta = \frac{\Gamma}{[(N+1)\Gamma + 2\varepsilon]\lambda}.$$

Note that (B2) is a special case of (A30) in which $\eta \to \infty$. This is because the corporate insiders observe security-specific information which is not correlated with the systematic factor information observed by the outside professionals. In the same way, corporate insider $m \in \{1, 2,\ldots, M\}$ wants to find a trading strategy which solves his portfolio selection problem

$$\text{(B3)} \qquad \underset{\Delta_m}{\text{Max}}\ \tilde{\Delta}_m \left\{E\left[\tilde{x} \mid \tilde{Y}, I\right] - R\,E\left[\tilde{S} \mid \tilde{Y}, I\right]\right\}.$$

The procedure of finding Δ_m mimics the one given by (A2) - (A14) except for the fact that $Y = e + i$ replaces $y = x + h$. In this way, the trading strategy of insiders is given by equation (6.9) where the trading intensity

$$\text{(B4)} \qquad b = \frac{\Phi}{(M+1)(\Phi + \iota)\lambda},$$

in which

$$\text{(B5)} \qquad \Phi = \operatorname{var}(\tilde{e} \mid \tilde{y}_\bullet = y_\bullet) = \operatorname{var}(\tilde{e}) - \frac{\operatorname{cov}^2(\tilde{e}, \tilde{y}_\bullet)}{\operatorname{var}(\tilde{y}_\bullet)} = \frac{\phi\,\varphi}{\phi + \varphi}.$$

This is a version of (A14) where the symbols are changed due to the new assumptions (thus, b replaces β, Φ replaces Γ, and ι replaces η) and the term $N\,\beta\,\lambda$ is zero as the two types of speculators now observe uncorrelated information. Notice also that (B5) equals (6.13). It follows from (B2) and (B3) that the relationship between b and β is given by (6.11) where **a** is given by (6.12). The next step is to use (6.8) and (6.9) to find that the net order flow

$$\text{(B6)} \qquad \tilde{z} = \beta\left[M a \tilde{e} + N \tilde{x} + \sum_{n=1}^{N} \tilde{e}_n + M a \tilde{i}\right] + \tilde{u} - \beta\left[M a E[\tilde{e} \mid \tilde{y}_\bullet = y_\bullet] - N E[\tilde{x} \mid \tilde{y}^* = y^*]\right].$$

Then I use this to derive the price sensitivity

$$\text{(B7)} \qquad \lambda = \frac{\operatorname{cov}(\tilde{x}, \tilde{z} \mid I)}{\operatorname{var}(\tilde{z} \mid I)} = \frac{\beta\,(N\Gamma + M\,a\,\Phi)}{\beta^2\left[N\left[(N\Gamma + \varepsilon)\right] + M^2 a^2 (\Phi + \iota)\right] + \sigma}.$$

I substitute (B2) into (B7) and solve for λ. The result is given by (6.15). I the substitute (6.15) back into (B2) and obtain (6.10). The price function must, as in the previous appendix, be linear in the order flow and is therefore given by (6.14). This completes the proof of lemma 2.2.

REFERENCES

Admati, A. R., 1989, "Information in Financial Markets: The Rational Expectations Approach," Discussion in S. Bhattacharya and G. M. Constantinides, "Financial Markets and Incomplete Information: Frontiers of Modern Financial Theory," Volume 2, Rowman and Littlefield, 139 - 152.

Admati, A. R., 1991, "The Informational Role of Prices: A Review Essay," Journal of Monetary Economics, 347 - 361.

Admati, A. R., and P. Pfleiderer, 1988, "A Theory of Intraday Patterns: Volume and Price Variability," Review of Financial Studies, 3 - 40.

Admati, A. R., and P. Pfleiderer, 1989, "Divide and Conquer: A Theory of Intraday and Day-of-the-Week Mean Effects," Review of Financial Studies, 189 - 223.

Admati. A. R., and P. Pfleiderer, 1991, "Sunshine Trading and Financial Market Equilibrium," Review of Financial Studies, 443 - 481.

Back, K., 1992, "Insider Trading in Continuous Time," Review of Financial Studies, 387 - 409.

Bhushan, R., 1991, "Trading Costs, Liquidity, and Asset Holdings," Review of Financial Studies, 343 - 360.

Bikhchandani, S., D. Hirshleifer, and I. Welch, 1992, "A Theory of Fads, Fashion, Custom, and Cultural Change as Informational Cascades," Journal of Political Economy, 992 - 1026.

Black, F., 1986, "Noise," Journal of Finance, 529 - 543.

Caballé, J., 1990, "Production and Transmission of Information in Financial Markets," Working Paper, Universitat Autònoma de Barcelona.

Dubey, P., J. Geanakoplos, and M. Shubik, 1989, "The Revelation of Information in Strategic Market Games: A Critique of Rational Expectations Equilibrium," Journal of Mathematical Economics, 105 - 137.

Duffie, D., 1992, "Dynamic Asset Pricing Theory," Princeton University Press.

Dutta, P. K., and A. Madhavan, 1991, "Dynamic Insider Trading," Working Paper, Columbia University.

Fishman, M. J., and K. M. Hagerty, 1992, "Insider Trading and the Efficiency of Stock Prices," Rand Journal of

Economics, 106 - 122 .

Foster, F. D., and S. Viswanathan, 1990, "A Theory of Interday Variations in Volumes, Variances, and Trading Costs in Securities Markets," Review of Financial Studies, 593 - 624.

Foster, F. D., and S. Viswanathan, 1991, "Public Information and Competition: Their Effects on Trading Volume and Price Volatility," Working Paper, The Fuqua School of Business, Duke University.

Foster, M. M., and T. J. George, 1992, "Anonymity in Securities Markets," Journal of Financial Intermediation, 168 - 206.

Fudenberg, D., and J. Tirole, 1991, "Game Theory," MIT-Press.

Gennotte, G., and H. Leland, 1990, "Market Liquidity, Hedging and Crashes," American Economic Review, 999 - 1021.

Glosten, L. R., 1989, "Insider Trading, Liquidity, and the Role of the Monopolist Specialist," Journal of Business, 211 - 235.

Glosten, L. R., and P. R. Milgrom, 1985, "Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders," Journal of Financial Economics, 71 - 100.

Goldberger, A. S., 1991, "A Course in Econometrics," Harvard University Press.

Grossman, S., 1976, "On the Efficiency of Competitive Stock Markets where Traders have Diverse Information," Journal of Finance, 573 - 584.

Grossman, S., 1989, "The Informational Role of Prices," MIT Press.

Grossman, S., and J. E. Stiglitz, 1980, "On the Impossibility of Informationally Efficient Markets," American Economic Review, 393 - 408.

Hellwig, M. F., 1980, "On the Aggregation of Information in Competitive Markets," Journal of Economic Theory, 477 - 498.

Holden, C. W., and A. Subrahmanyam, 1992, "Long-Lived Private Information and Imperfect Competition," Journal of Finance, 247 - 270.

Huang, C., and R. H. Litzenberger, 1988, "Foundations for Financial Economics," North-Holland.

Hughson, E., and D. Bernhardt, 1990, "Intraday Trade in Dealership Markets," Working Paper, Department of Economics, California Institute of Technology, Pasadena, June.

Krishnan, M., and J. Caballé, 1990, "Insider Trading and Asset Pricing in an Imperfectly Competitive Multi-Security Market," Working Paper, Krannert Graduate School of Management, Purdue University, January.

Kyle, A. S., 1984, "Market Structure, Information, Futures Markets, and Price Formation," In G. G. Storey, A. Schmitz, and A. H. Sarris, eds., "International Agricultural Trade: Advanced Reading in Price Formation, Market Structure, and Price Instability," Westview Press, 45 - 64.

Kyle, A. S., 1985a, "Continuous Auctions and Insider Trading," Econometrica, 1315 - 1335.

Kyle, A. S., 1985b, "On Incentives to Produce Private Information with Continuous Trading," Working Paper, Woodrow Wilson School, Princeton University.

Kyle, A. S., 1989, "Imperfect Competition, Market Dynamics, and Regulatory Issues," Discussion in S. Bhattacharya and G. M. Constantinides, "Financial Markets and Incomplete Information: Frontiers of Modern Financial Theory," Volume 2, Rowman and Littlefield, 153 - 161.

Leach, J. C., and A. N. Madhavan, 1992, "Intertemporal Price Discovery by Market Makers: Active versus Passive Learning," Journal of Financial Intermediation, 207 - 235.

Lindsey, R. R., 1990, "Market Makers, Asymmetric Information and Price Information," Finance Working Paper #204, Walter A. Haas School of Business, University of California, Berkeley, December.

Lindsey, R. R., and U. Schaede, 1992, "Specialist vs Saitori: Market Making in New York and Tokyo," Financial Analysts Journal, July - August, 48 - 58.

Pagano, M., and A. Röell, 1990, "Trading Systems in European Stock Exchanges: Current Performance and Policy Options," Economic Policy, 65 - 115.

Pagano, M., and A. Röell, 1992, "Auction and Dealership Markets: What is the Difference?" European Economic Review, 613 - 623.

Pfleiderer, P., 1984, "The Volume of Trade and The Variability of Prices: A Framework for Analysis in Noisy Rational Expectations Equilibria," Working Paper, Graduate School of Business, Stanford University.

Schwartz, R., 1988, "Equity Markets: Structure, Trading, and Performance," Harper and Row.

Shleifer, A., and L. H. Summers, 1990, "The Noise Trader Approach to Finance," Journal of Economic Perspectives, 19 - 33.

Spiegel, M., and A. Subrahmanyam, 1992, "Informed Speculation and Hedging in a Noncompetitive Securities Market," Review of Financial Studies, 307 - 329.

Subrahmanyam, A., 1991,"A Theory of Trading in Stock Index Futures," Review of Financial Studies, 17 - 51.

Yavas, A., 1992, "Marketmakers versus Matchmakers," Journal of Financial Intermediation, 33 - 58.

CHAPTER 3

ON THE PROPERTIES OF FINANCIAL MARKETS WITH A CHANGING SUPPLY OF CORPORATE INSIDERS

First draft: October 1990,
Current revision: November 1992.

ABSTRACT

Under certain conditions, insider trading causes the trading intensities of all superiorly informed traders to decrease, and thereby reduces the equilibrium bid ask spread. On the other hand, it increases the market depth, the expected trading volume, the volatility, and the informativeness of the transaction price. This is a flavor of the numerous and rather complex effects which have to be taken into account when stock market regulators propose changes in the law governing the trades by corporate insiders.

3.1 INTRODUCTION

I use the securities market equilibrium characterized by lemma 2.1, and analyze the changes in some of its basic properties when the law regulating insider trading is changed from allowing to prohibiting such trades. Some of the corporate insiders (or their tippees) may find it optimal to trade illegally. This is because there are assumed to be significant costs of control as a result of the camouflage provided by the outsiders, suggesting that it is not optimal for the regulatory agency to enforce the ban such that all the insiders are kept out of the market (see sections 5.4 - 5.5).

The focus is on the effects of this regulatory change on market characteristics such as the trading intensities of the superiorly informed speculators, the price sensitivity and the equilibrium bid ask spread set by the market makers, the market liquidity measured by the expected trading volume and the depth, and the market efficiency measured by the volatility and the informativeness of the transaction price. The effects caused by insider trading on the expected welfare of the future shareholders (i.e., the various types of traders) are left for chapter 4, and chapter 5 analyzes the effects on the expected welfare of the current shareholders. Later chapters extend the discussion by taking into account other effects relevant for the insider trading debate.

In many respects, this chapter is close to Leland (1992) who analyzes insider trading within a rational expectations framework. The demand for shares comes from a single insider who observes perfect information and recognizes his impact on the transaction price, from outside arbitrageurs who trade on information generated by observing the market price, and from liquidity traders who are trading randomly. Shares are supplied by a firm which issues shares to maximize the expected profit of current shareholders. Leland shows that when insider trading is permitted, the average stock price will be higher, the liquidity of the market will be less, the current price will be more volatile, the future price volatility given the current price will be lower, and the current price will be more highly correlated with the future price. To some extent, these important findings are confirmed in my analysis. Nonetheless, additional insight is offered, for instance, by recognizing competition among the corporate insiders.

I start by assuming a financial market design where the supply of market professionals is fixed and given outside the model. In this setting, several interesting properties relevant for evaluating the effects of insider trading are identified:

If insider trading is prohibited, the market professionals tend to intensify their trading. This is because a reduction in the supply of corporate insiders reduces the competition among the superiorly informed, allowing the outside professionals to increase their trading without revealing too much information to the price setting market makers. But if some of the insiders are trading illegally, the opposite might happen because few speculators have more market power than many. Accordingly, the corporate insider trade harder when it is illegal than when it is legal. The reason is that less competition, together with no fear of detection because of the perfect camouflage provided by the professionals and the liquidity traders, allows the corporate insiders to increase their trades without revealing too much information to the price setting market makers or being caught by the stock market regulators.

If insider trading is prohibited, the price sensitivity and thereby the equilibrium bid ask spread may easily increase. This happens if the reduction in the supply of corporate insiders leads to less competition and thereby to less information in the equilibrium order flow. Then the price setting market makers face an increased adverse selection problem, and, consequently, they have to increase the bid ask spread. This is inconsistent with King and Röell (1988) who on page 168 claim that "market makers, of course, recognize the danger presented by the better informed traders or competitors and respond by widening their bid-ask spread." Nevertheless, if there initially is just one insider trading in each security, effectively prohibiting insider trading indeed decreases the bid ask spread.

I measure the market liquidity by the expected trading volume and the market depth, and show that a reduction in the supply of corporate insiders may reduce both measures. The expected trading volume is reduced because insider trading increases stock trading measured by the variability of the order flow, and the market depth is reduced because the intermediaries represented by the market makers face an increased adverse selection problem to the pricing of securities. Insider trading may promote the liquidity of the securities market. Nevertheless, if the firms are small with only a few employees, the market depth may actually increase because in this case the adverse selection problem of the price setting intermediaries is reduced. The same may happen if the supply of outsiders is elastic in the supply of corporate insiders. Finally, insider trading is shown to accelerate the resolution of uncertainty from the future to the present period. This means that the volatility of the current transaction price increases with insider trading, but the uncertainty of the future value given the current price is reduced by insider trading. Thus, insider trading improves the informativeness, but increases volatility of the transaction price.

In the second part of this chapter, I analyze the financial market described by lemma 2.1 in which the supply of market professionals is determined as part of the equilibrium. This is easily done by letting the outside professionals enter into the market as long as their expected trading profit exceeds the cost of acquiring private information.

If I assume a very elastic supply of market professionals, the following effects are identified: Allowing corporate insider to trade on superior information causes some of the professionals to leave because they are not able to cover their informational investments due to intensified competition. This, on the other hand, reduces the competition and allows harder trading by the remaining speculators. It is shown that insider trading decreases the price sensitivity and thereby the equilibrium bid ask spread. The reason is that the exit of market professionals reduces the adverse selection problem faced by the price setting market makers, and therefore they may reduce the bid ask spread and simultaneously decrease the market depth. As in the special case analyzed by Fishman and Hagerty (1992), insider trading may reduce the ability of the price system to transmit information because privately informed outsiders are kept out of the securities market by the insiders. The amount of inside information reflected in the price increases, but it is dominated by the reduction in the amount of privately acquired information. This indicates that the effects of insider trading on a stock market exchange with an elastic supply of market professionals are even less clear cut than in the case with fixed supply discussed above. Notice that in a market with elastic supply, we obtain the same effects as in the fixed supply market by reducing the supply elasticity.

This remainder of the chapter is structured as follows. Section two draws attention to the trading intensities of both corporate insiders and market professionals, focusing on the difference between the two and on the changes in their trading intensities caused by an exogenous shift in the insider trading regulations. Then, in section three, I analyze the price sensitivity and the bid ask spread which both are determined in equilibrium by the price setting market makers. Sections four and five analyze what happens to the market depth, the expected trading volume, the informativeness, and volatility of the transaction price. In section six, I analyze the trading intensities of informed speculators, the price sensitivity, and the market efficiency in a corresponding securities market with an elastic supply of market professionals. Section seven concludes the chapter. Some formal proofs are found in the appendices together with a numerical example used throughout the chapter to illustrate the properties of the stock market equilibrium.

3.2 TRADING INTENSITIES

This section compares the trading intensities within and across equilibria. The first comparison means that I contrast the trading intensity based on information from external sources with the trading intensity based on information from internal sources. Then I compare the trading intensities when insider trading is allowed with the corresponding trading intensities when insider trading is prohibited by the stock market regulators.

2.1 Comparison of the two types of informed speculators

The trading intensity on private information and the trading intensity on inside information are given in lemma 2.1 where, according to corollary 2.2, μ replaces M when L = **B**.

Proposition 3.1: *If L = **A**, the trading intensities of superiorly informed speculators β and B on the stock market exchange $[(\theta_{nkt}, \Delta_{mkt}, u_{dkt}), S_{kt};\ k \in \{1, 2, ..., K\},\ t \in \{0, 1, ..., T_k\text{-}1\}]$ are given by (2.3.3) and (2.3.4) in lemma 2.1. They are related since*

$$\frac{dB}{d\beta} = \alpha, \tag{2.1}$$

where $\alpha > 0$ is given by (2.3.6).

Proof: This follows by differentiating (2.3.4) with respect to the trading intensity of market professionals. Q.E.D.

According to (2.3.4), the trading intensity of corporate insiders equals the trading intensity of market professionals multiplied with a factor α, depending on the number of corporate insiders, the potential amount of private information, and the precision of inside and privately acquired information.

Proposition 3.2: *If*

$$\mu < \frac{2\,\varepsilon - \eta}{\eta},\ \textit{then}\ \mathrm{B} > \beta. \tag{2.2}$$

On the contrary, if

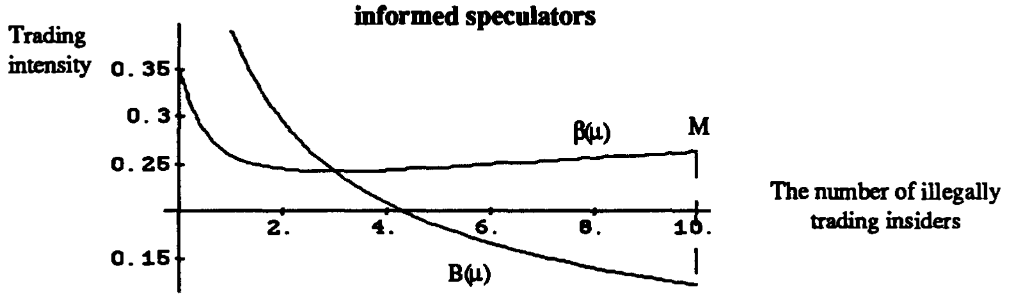
$$\mu \geq \frac{2\,\varepsilon - \eta}{\eta},\ \textit{then}\ \mathrm{B} \leq \beta. \tag{2.3}$$

If $\eta = 0$, $B > \beta$ for all $\mu < \infty$ (if $\eta = 0$ and $\mu \to \infty$, $B = \beta = 0$).

Proof: If $\alpha > 1$, then $\mathrm{B} > \beta$ (see (2.3.4)). I use corollary 2.2 and equation (2.3.6), and find (2.2) by solving $\alpha(\mu) > 1$ with respect to μ. The inequality given by (2.3) follows analogously. Finally, the last sentence in the proposition follows directly from (2.2), and the parenthesis follows from the fact that $\alpha(\mu \to \infty) = 0$, suggesting that $\mathrm{B} = 0$, and if $\eta = 0$ and $\mu \to \infty$, $\beta = 0$ (see (2.3.3)). Q.E.D.

This is consistent with Fishman and Hagerty (1992) who on page 108 observe that a single insider trades harder than any of the market professionals. Their observation can be proven by observing that $\mu = 1 < (2\ \varepsilon - \eta) / \eta$ because $\varepsilon > \eta$ (see (2.2.10)). In my model, the opposite may happen if there are several corporate insiders. Figure 3.1 illustrates the trading intensities as functions of μ, using the numerical values given in table 3.3 (see appendix D).

FIGURE 3.1 Trading intensities of privately informed speculators



We observe that as long as $\mu < 3$, the corporate insiders trade harder or more intensively than the two market professionals. Notice also that $\beta_\bullet(\mu_\beta = 3) = 0.243 \leq \beta(\mu)$ for all μ, implying that, in this example, the trading intensity of the professionals reaches its minimum when there are only three corporate insiders in the securities market.

2.2 Comparison across equilibria

I compare the trading intensities of market professionals and corporate insiders when insider trading is allowed with their trading intensities in a corresponding market where insider trading is outlawed by the stock market regulators.

Market professionals

According to (2.3.3), the trading intensity of market professionals depends on the number of traders with inside information.

Proposition 3.3: *If the supply of corporate insiders changes, the direction of the effect on the trading intensity of market professionals is determined by*

(2.4)
$$\mathrm{Sgn}\left(\frac{d\beta}{d\mu}\right) = -\,\mathrm{Sgn}(\Gamma + (1-\mu)\,\eta\,).$$

If $\eta > 0$, $\beta(\mu = 0) = \beta(\mu \to \infty) > 0$. However, if $\eta = 0$, $\beta(\mu = 0) > \beta(\mu \to \infty) = 0$.

Proof: The sign indicated by (2.4) follows straightforwardly by differentiating β with respect to μ where β is given by (2.3.3). The value $\beta(\mu = 0)$ is given by (2.5.3), and we observe directly from (2.3.3) that as long as $\eta > 0$, $\beta(\mu \to \infty) = \beta(\mu = 0)$ because

(2.5) $$\lim_{\mu \to \infty} \mu \alpha^2 = 0.$$

If $\eta = 0$, $\beta(\mu \to \infty) = 0$ because α is independent of μ. Q.E.D.

If there are infinitely many corporate insiders observing perfect information (i.e., $\mu \to \infty$ and $\eta = 0$), the equilibrium price converges towards its fully revealing limit. The market professionals have not any incentive to trade because they do not possess any private information. On the other hand, if $\eta > 0$ and $\mu \to \infty$, the transaction price reveals y, but it is not a sufficient informational statistic, implying that the market professionals have an incentive to trade, because some of their information is still intact and therefore useful for trading.

An infinite number of corporate insiders do not have any superior information and consequently do not contribute to the adverse selection problem to the pricing of the securities faced by the intermediaries. The adverse selection problem is caused by the market professionals as is the case when there are no corporate insiders in the securities market. This implies that as long as $\eta > 0$, the trading intensities of market professionals are identical when $\mu = 0$ and $\mu \to \infty$. The limits are confirmed in figure 3.1 where $\beta(\mu = 0) = \beta(\mu \to \infty) = 0.354$.

If the supply of corporate insiders changes exogenously, the effect on the trading intensity of market professionals may be split into two parts:

(2.6) $$\frac{\mathrm{d}\beta}{\mathrm{d}\mu} = \frac{\mathrm{d\,Competition}}{\mathrm{d}\mu}\,\mathrm{Depth} + \mathrm{Competition}\,\frac{\mathrm{d\,Depth}}{\mathrm{d}\mu},$$

because (see (2.A30))

(2.7) $$\beta = \frac{\Gamma}{N\Gamma + (\mu + 1)(\Gamma + \eta)\alpha} \cdot \frac{1}{\lambda}.$$

The first factor may be interpreted to represents the direct competition among the informed traders, and the second factor is the market depth which reflects the indirect competition through the adverse selection problem faced by the intermediaries (see section 3.4 for a formal definition of the depth). Table 3.1 summarizes the effects on β caused by an exogenous change in μ.

TABLE 3.1: Effects on β caused by $\Delta\mu$

$\Delta\mu$	Dc	De	Total
$\mu \in [0, \mu_\lambda]$	-	-	-
$\mu \in (\mu_\lambda, \mu_\beta]$	-	+	-
$\mu \in (\mu_\beta, \infty)$	-	+	+

Dc = Direct competition, De = Depth effect, and μ_λ, μ_β are constants ($\mu_\lambda < \mu_\beta$)

First, if μ increases from 0 to μ_λ (which equals approximately 1), then the effect via the depth and the direct effect on competition are both negative. This implies that market professionals act strategically and reduce their trading intensity to prevent too much information to be revealed by the net order flow. Secondly, if μ expands from μ_λ to μ_β (= $(\Gamma + \eta) / \eta$), the direct competition effect is as always negative, but the adverse selection problem is reduced and thereby allows a greater market depth. The reason is increased competition among the corporate insiders. The effect caused by direct competition dominates and the professionals still find it optimal to reduce $\beta(\mu)$ further. Finally, for expansions beyond μ_β, the reduction in adverse selection dominates the increased competition between the market professionals and the illegally trading insiders. This means that for $\mu > \mu_\beta$, the trading intensity $\beta(\mu)$ increases with μ. If $\eta = 0$, the competition effect between the two types of informed traders dominates the depth effect, and $\beta(\mu)$ falls for all μ.

Corollary 3.1: *Suppose L changes from **A** to **B** in a small company (meaning that $1 \leq M \leq M_\beta = (\Gamma + \eta) / \eta$), then*

$$\beta(\mu) \geq \beta(\mathrm{M}). \tag{2.8}$$

If the company is large (that is, $M > M_\beta$), the opposite might happen if the enforcement of the law is *inadequate.*

Proof: This result follows straightforwardly from (2.4) since $\mu \leq M$. Q.E.D.

If insider trading is prohibited in a small company, reduced competition from corporate insiders allows the market professionals to use their information more aggressively. This is not always the case in large companies.

Corporate insiders

According to (2.3.4), the trading intensity of corporate insiders depends, among other things, on their own supply.

Proposition 3.4: *If the number of trading insiders changes exogenously, the effect on their trading intensity is negative. Thus,*

$$\frac{dB}{d\mu} < 0. \tag{2.9}$$

The limit $B(\mu = 0) > B(\mu \to \infty) = 0$.

Proof: It is straightforward by the use of (2.3.4) to show that the derivative of B is negative. If insider trading is effectively prohibited, $B(\mu = 0)$ is given by (2.5.4) where $\alpha^{`} = (\Gamma + 2\,\varepsilon) / (\Gamma + \eta)$. We see directly that $B(\mu = 0) > 0$. Finally, I use (2.3.4) and find that $B(\mu \to \infty) = 0$ because

$$\lim_{\mu \to \infty} \alpha(\mu) = 0. \tag{2.10}$$

Q.E.D.

If $\mu \rightarrow \infty$, y is revealed by S. This means that the corporate insiders have not any privileged information and they therefore have no incentive to trade. If, on the other hand, $\mu = 0$, the trading intensity reaches its maximum due to maximum market power (ignoring the integer problem). This is confirmed in figure 3.1 where $B(\mu = 0) = 0.707 > B(\mu \rightarrow \infty) = 0$.

Nevertheless, the total trade of corporate insiders does not converge toward zero when their number grows to infinity. This is because

$$\text{(2.11)} \qquad \lim_{\mu \to \infty} \mu \alpha = \frac{\Gamma + 2\varepsilon}{\eta},$$

implying that

$$\text{(2.12)} \qquad \lim_{\mu \to \infty} \mu B = \frac{\Gamma + 2\varepsilon}{\eta} \sqrt{\frac{\sigma}{N(\Gamma + \varepsilon)}} > 0.$$

This means that the insiders indeed influence the net order flow at the limit when they are infinitely many, and thereby reveal the information content of their common signal to outsiders inferring information from the net order flow.

Individual trading on inside information decreases with the number of illegally trading insiders because competition among the insiders in exploiting their common signal increases as their number increases. In this way, the competition effect dominates the adverse selection effect for all μ. I may claim that insiders act strategically and reduce their trades in order not to reveal too much information.

Corollary 3.2: *Suppose L changes from **A** to **B**, then*

$$\text{(2.13)} \qquad B(\mu) \geq B(M).$$

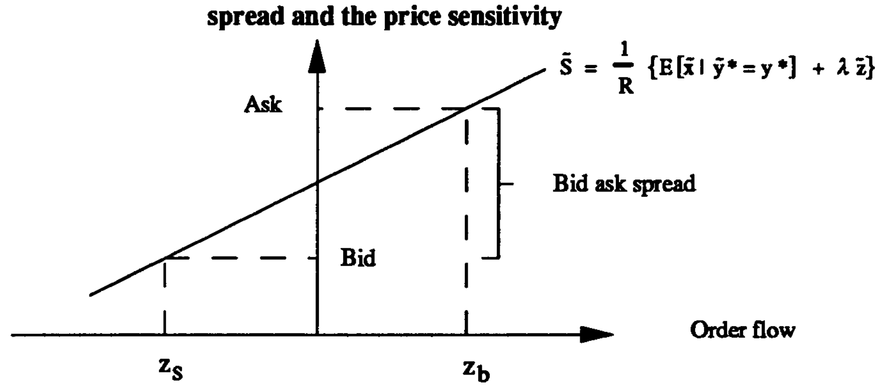
Proof: This follows from (2.9) since $\mu \leq M$. Q.E.D.

Corporate insiders who are trading illegally on privileged information trade more aggressively than when such trading is allowed.

3.3 BID ASK SPREAD

From a security trader's perspective, the bid ask spread is the difference between the ask and bid prices. A trader who buys at market pays the ask price, and a trader who sells at market receives the bid price. Hence, the bid ask spread is the cost of a round-trip; buying and then selling a given number of shares. Figure 3.2 illustrates how the bid ask spread depends on the order size.

FIGURE 3.2 Relationship between the bid ask spread and the price sensitivity



If the traders first buy z_b and then sell z_s where $|z_b| = |z_s|$, they expect to loose the difference between the ask and bid price. The spread, now from a market maker's perspective, is

$$\tilde{s} = \frac{\lambda}{R}(\tilde{z}_b - \tilde{z}_s). \tag{3.1}$$

In this way, the bid ask spread is increasing with the price sensitivity and the net order size. This suggests that when the market makers act as dealers, their revenue comes from the bid ask spread, and when they act as brokers, their revenue comes from the commissions on each transaction. The commissions are normalized to zero without changing any results. I unify the round-trip volume and the spread becomes a deterministic parameter:

$$(3.2) \qquad s = \frac{2}{R}\lambda.$$

Generally, the spread is lowered if the uninformed trading activity is increased, the informed trading activity is reduced, the market makers' risk of holding an unwanted position is reduced, and the competition among the market makers is intensified. As a result, there are three components in the bid ask spread; a component reflecting adverse selection, a component reflecting risk aversion of the intermediaries, and, finally, a component reflecting the competition in the broker - dealership market. The two last components are not present in this model, but are taken into account in chapters 7 - 8; see also chapter 5 for an extension taking explicitly into account the costs of market making.

Proposition 3.5: *The market makers set the equilibrium price sensitivity depending on the supply of corporate insiders:*

$$(3.3) \qquad \mathrm{Sgn}\left(\frac{d\lambda}{d\mu}\right) = -\mathrm{Sgn}\left[\frac{2\Gamma}{N\Gamma + (\mu + 1)(\Gamma + \eta)\alpha} - \frac{\alpha(\Gamma + (1 - \mu)\eta)}{N(\Gamma + \varepsilon) + \mu(\Gamma + \eta)\alpha^2}\right].$$

We observe that when $\mu \geq \mu_\lambda$ (where μ_λ be determined by $d\,\lambda(\mu_\lambda) / d\,\mu = 0$), $d\,\lambda / d\,\mu < 0$. If $\eta > 0$, $\lambda(\mu = 0) > \lambda(\mu \to \infty) > 0$. However, if $\eta = 0$, $\lambda(\mu \to \infty) = 0$.

<u>Proof</u>: I differentiate (2.3.8) to get (3.3). We see directly that the sign is negative for large μ. If $\eta = 0$, then μ_λ is easy to find. However, if $\eta > 0$, the solution is complex but easy to find numerically. I use (2.5), (2.11), and (2.3.8) to show that

$$(3.4) \qquad \lambda(\mu \to \infty) = \frac{\Gamma}{N\Gamma + \frac{(\Gamma + 2\varepsilon)(\Gamma + \eta)}{\eta}}\sqrt{\frac{N(\Gamma + \varepsilon)}{\sigma}}.$$

This limit is smaller than $\lambda(\mu = 0)$ given by (2.5.6). Finally, when $\eta = 0$, we observe that $\lambda(\mu \to \infty) = 0$.

Q.E.D.

If the supply of corporate insiders observing perfect information approaches infinity, the underlying value of the firm is completely revealed through the net order flow. There is no price differentiation problem, and the market makers are able to set the equilibrium bid ask spread to zero. However, if they observe noisy information, the price sensitivity does not converge towards zero as the supply grows to infinity, because the corporate insiders are assumed to share one common signal. This suggests that if all inside information is transmitted into the net order flow, there is still private information held by the market professionals who obtain information from external sources.

Informational asymmetry leads to a price sensitivity greater than zero and thereby to a positive bid ask spread. The reason that $\lambda(\mu = 0) > \lambda(\mu \to \infty)$ is that corporate insides reveal information and, since y is correlated with $\{y_n;\ n = 1, 2, ..., N\}$, they also reveal some of the information acquired by the market professionals. This means that the market makers are able to set a lower price sensitivity when there is a continuum of insiders.

It is possible by the use of (2.2.19) to identify two effects caused by an exogenous change in the supply of corporate insiders:

$$\text{(3.5)} \qquad \mathrm{Sgn}\left(\frac{d\lambda}{d\mu}\right) = \mathrm{Sgn}\left(\frac{d\,\mathrm{cov}(\tilde{x}, \tilde{z} \mid \tilde{y}^* = y^*)}{d\,\mu} - \lambda\,\frac{d\,\mathrm{var}(\tilde{z} \mid \tilde{y}^* = y^*)}{d\,\mu}\right),$$

The first term represents the information effect. It tends to be positive because insider trading transmits information into the order flow, leading to a situation in which the market makers are observing better or more precise information. The second term represents the informed volume effect. It tends to be negative. The reason is that with insider trading orders from informed increases relative to orders from uninformed. Table 3.2 summarizes the effects.

TABLE 3.2: Effects on λ caused by $\Delta\mu$

$\Delta\mu$	Ie	Ve	Total
$\mu \in [0, \mu_\lambda]$	+	-	+
$\mu \in (\mu_\lambda, \infty)$	+	-	-

Ie = Information effect, Ve = Volume effect, and μ_λ is a constant.

As confirmed by figure 3.3, the positive information effect dominates for small μ and the negative volume effect dominates for larger μ.

Corollary 3.3: *Suppose L changes from A to B in the securities market characterized by lemma 2.1 in which $M > M^* > 0$ (where $M^* > 0$ is determined by $\lambda(M^*) = \lambda(\mu = 0)$), then*

$$\lambda(\mu) \geq \lambda(\mathrm{M}). \tag{3.6}$$

Proof: This follows from (3.3) since $\mu \leq$ M. Q.E.D.

If insider trading were allowed in companies with a large number of insiders, the bid ask spread would be lowered even if the enforcement is complete. This is consistent with Leland (1992), page 877 who observes that the average price will be higher when a single insider is trading, but contradicts the claim in King and Röell (1988) that insider trading increases the bid ask spread; see also Glosten and Milgrom (1985). These authors do not recognize the competition effect caused by several corporate insiders. Figure 3.3 gives an example.

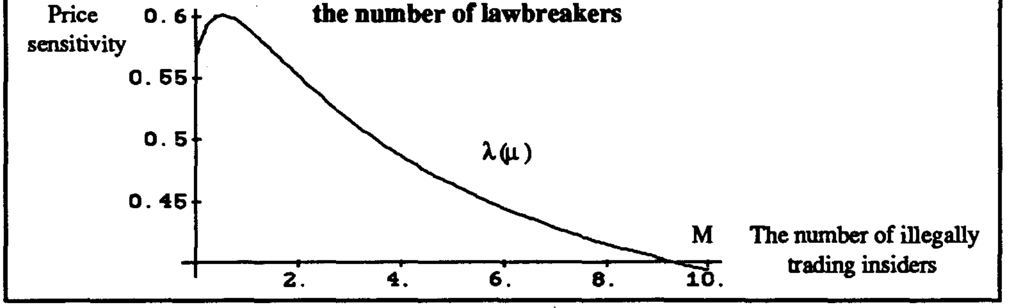


FIGURE 3.3 Price sensitivity as a function of the number of lawbreakers

In this example, the price sensitivity (and thereby the bid ask spread) increases if the supply of corporate insiders increases from zero to one ($\lambda(\mu = 0) = \lambda(M^* = 1.641) = 0.566 < \lambda(\mu = 1) = 0.591$), and is reduced if the supply expands further. Note that, $\lambda(\mu_\lambda = 0.512) = 0.601 \geq \lambda(\mu)$ for all μ. The spread is positive even when there are no insiders. This holds as long as the market professionals are trading on privately acquired information and thereby creating an adverse selection problem to the pricing of securities. Finally, note that $\lambda(\mu \to \infty) = 0.257$ which is less than $\lambda(\mu = 0) = 0.566$.

The results in this section depends critically on the assumption that the two types of informed speculators observe correlated information which means that the corporate insiders reveal information hold by the market professionals and the other way around. Figure 4.5 illustrates the price sensitivity when the two types of informed speculators observe uncorrelated information. In this case, $\lambda(\mu)$ is always minimized if $\mu = 0$, maximized if μ is approximately 1, and $\lambda(\mu \to \infty) = \lambda(\mu = 0)$.

3.4 LIQUIDITY

The concept "market liquidity" is closely tied to the trading volume, but it encompasses a number of transactional properties. Following Black (1971), the liquidity of the market is generally measured by the depth, the tightness, and the resiliency:

- The depth is defined as the lack of change in the market price caused by a unit change in the order flow. In other words, the market depth is the size of an order flow innovation required to change the price a given amount.
- The tightness is defined as the lack of costs when a trader is turning around a position in the securities

market over a short period of time. Thus, the tightness is closely related to the depth, and a low bid ask spread is consistent with a tight market.

- The resiliency is defined as the speed with which prices recover from a random, uninformative shock, suggesting that a resilient market is characterized by no systematic price bubbles which means that prices are near the "true" underlying values.

Roughly speaking, a liquid market is one which is infinitely deep and tight and is so resilient that the price reflects the underlying value (see Kyle (1985), pages 1316 - 1317). Another concept relevant for evaluating the liquidity of a market is, again according to Black (1971), the immediacy. That is, the market's ability to execute orders when they arrive. In this model, the market is immediate and in this respect liquid. This is because I have assumed a dealership market approach where the price setting market makers always stand ready to take the opposite position vis-à-vis the security traders. Hence, no orders have to wait for a trader to appear and take the other side of the market as might be the case in some broker auction markets (then called search markets).

In the rest of this section, I measure the liquidity of the securities market by the depth and by the expected trading volume.

4.1 Depth

I follow the approach in Kyle (1985) and measure the market depth by the inverse of the price sensitivity. This is because

$$\frac{d\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m + \tilde{u}\right)}{d\,\tilde{S}} = \frac{1}{\lambda}. \tag{4.1}$$

The depth (and thereby the liquidity) increases when the slope of the market clearing line λ decreases. This suggests that the market makers react to the information content of the order flow through the liquidity of the market. The process works so that if the adverse selection problem faced by the market makers is becoming too severe to handle, they react by making the stock market exchange less liquid simply by making the market clearing line in figure 3.2 steeper.

Corollary 3.4: Suppose L changes from A to B in a firm with M > M• corporate managers (where M• > 0 is defined by the equation $\lambda(M\bullet) = \lambda(\mu = 0)$, then

$$(4.2) \qquad \frac{1}{\lambda(\mu)} \leq \frac{1}{\lambda(M)}.$$

Proof: This follows from (3.3) since $\mu \leq M$. Q.E.D.

If insider trading is prohibited in a firm with many employees, the liquidity of the market is reduced (given an inelastic supply of market professionals and liquidity traders). This may also happen in small firms provided incomplete enforcement of the law. Leland (1992), who analyzes a framework with only one insider, claims on page 870 that the liquidity of the market is reduced by insider trading which is consistent with my findings when $\mu = 0$ and $M = 1$.

4.2 Expected trading volume

An alternative measure of market liquidity is the expected trading volume. It is defined as in Admati and Pfleiderer (1988) as the sum of the expected trading volume from the speculators, the liquidity traders, and the market makers where the expected volume from, e.g., the market professionals is measured by the variance of their net orders.

Lemma 3.2: The expected volume of trade on the stock exchange $[(\theta_{nkt}, \Delta_{mkt}, u_{dkt}), S_{kt}; k \in \{1, 2, ..., K\}, t \in \{0, 1, ..., T_k-1\}]$ given by lemma 2.1 equals

$$(4.3)\, E\left[\tilde{V} \mid \tilde{y}^* = y^*\right] = \sqrt{\sigma}\left[1 + \frac{\sqrt{N(N\Gamma + \varepsilon)} + M\alpha\sqrt{(\Gamma + \eta)} + \sqrt{(N + M\alpha)\left[N\Gamma + (M+1)(\Gamma + \eta)\alpha\right]}}{\sqrt{N(\Gamma + \varepsilon) + M(\Gamma + \eta)\alpha^2}}\right].$$

If insider trading is prohibited, then μ replaces M.

Proof: See appendix A.

The first term is the expected volume from the liquidity traders (if there are both discretionary and non-discretionary liquidity traders, $\sigma_0^{1/2} + \Sigma\ \sigma_d^{1/2}$ replaces $\sigma^{1/2}$), the second term is the expected volume from the market professionals, the third term is the expected volume from the corporate insiders, and the last term is the expected volume caused by the price setting market makers taking the net opposite position vis-à-vis the other traders.

Proposition 3.6: *If $\mu > M_\beta$, the expected trading volume in the security market characterized by lemma 2.1 tends to increase with the supply of corporate insiders:*

(4.4)
$$\frac{d\,E\left[\tilde{V} \mid \tilde{y}^* = y^*\right]}{d\,\mu} > 0.$$

If $\eta > 0$, then $E[V(\mu = 0) / y^*=y^*] < E[V(\mu \to \infty) / y^*=y^*] < \infty$. On the other hand, if $\eta = 0$, $E[V(\mu \to \infty) / y^*=y^*] \to \infty$.

Proof: I find that $Sgn(d\ E[\Sigma V_n \mid y^*=y^*] / d\ \mu) = - Sgn(\Gamma - (\mu - 1)\ \eta)$, $d\ E[\Sigma V_m \mid y^*=y^*] / d\ \mu > 0$, and $d\ E[\Sigma V_q \mid y^*=y^*] / d\ \mu > 0$ where V_n, V_m, and V_q are the volume from professional $n \in \{1, 2, ..., N\}$, insider $m \in \{1, 2, ..., M\}$, and market maker $q \in \{1, 2, ..., Q\}$. The last derivative implies that the total volume tends to increase with μ, hence $d\ E[V \mid y^*=y^*] / d\ \mu > 0$. However, if $\mu < M_\beta = (\Gamma + \eta) / \eta$, the increase in the volume from corporate insiders may be dominated by the decrease in the volume from market professionals. The limits are

(4.5)
$$E\left[\tilde{V}(\mu = 0) \mid \tilde{y}^* = y^*\right] = \sqrt{\sigma}\left[1 + \frac{\sqrt{N\Gamma + \varepsilon} + \sqrt{(N + 1)\Gamma + 2\,\varepsilon}}{\sqrt{\Gamma + \varepsilon}}\right], \text{ and}$$

$$(4.6)\ E\left[\tilde{V}(\mu \to \infty) \mid \tilde{y}^* = y^*\right] = \sqrt{\sigma}\left[1 + \frac{\sqrt{N(N\Gamma + \varepsilon)} + \frac{\Gamma + 2\varepsilon}{\eta}\sqrt{\Gamma + \eta} + \sqrt{\left(N + \frac{\Gamma + 2\varepsilon}{\eta}\right)\left[N\Gamma + \frac{(\Gamma + 2\varepsilon)(\Gamma + \eta)}{\eta}\right]}}{\sqrt{N(\Gamma + \varepsilon)}}\right].$$

We see that (4.6) is limited (if $\eta > 0$) and greater than (4.5). Q.E.D.

The expected trading volume tends to increase if the supply of corporate insiders increase. The reason is increased variability in the order flow. This tends to hold even for small μ as the increase in the expected volume from the corporate insiders usually dominates the decrease in the expected volume from the market professionals.

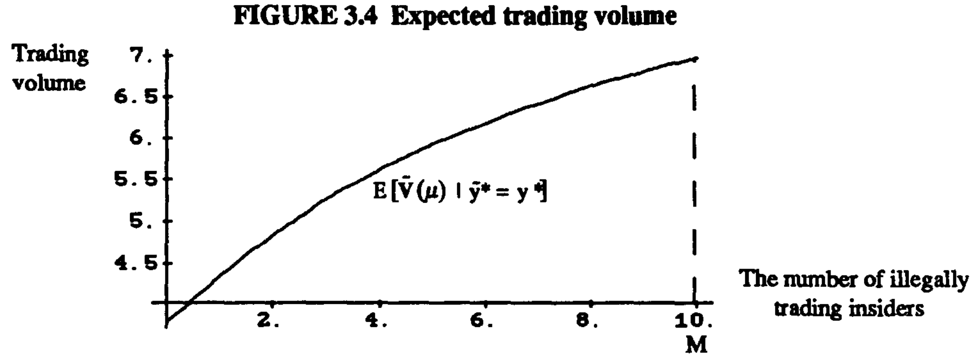
Corollary 3.5: *Suppose the L changes from A to B, then*

$$(4.7) \qquad E\left[\tilde{V}(M) \mid \tilde{y}^* = y^*\right] \geq E\left[\tilde{V}(\mu) \mid \tilde{y}^* = y^*\right].$$

Proof: This follows from (4.4) since $\mu \leq M$. Q.E.D.

If insider trading is prohibited by law (or contract), the expected trading volume decreases because some of the corporate insiders choose to leave the securities market to avoid the risk of being punished. Figure 3.4 illustrates using the data in table 3.3.

FIGURE 3.4 Expected trading volume



We see that the expected trading volume increases monotonically from 3.806 when $\mu = 0$ to 10.589 when $\mu \to \infty$.

3.5 VOLATILITY AND PRICE EFFICIENCY

Privately informed speculators reveal information when they submit orders to the intermediaries here represented by the market makers. The intermediaries set the transaction price and clear the market based on already disclosed information and new information revealed through the net flow of orders. In this way, the quoted bids and asks reveal information. Potential speculators, however, have no incentives to infer information generated as part of the equilibrium because it is not possible to make a profit on public knowledge. But, of course, the informed speculators know the price structure, and use it, before they execute their orders, to influence the information content to their advantage by holding some of it back. The speculators' strategic adjustments suggest that the informational role of prices is of interest because their expected profits depend on how much information that is revealed to the price setting market makers. Traders need an inefficiency in the price mechanism to generate trading profits. This raises at least two important questions: What determines the volatility of prices, and how much information is reflected in the price system?

5.1 Volatility

The volatility of the market prices is often used to describe financial markets; see, e.g., Miller (1991) or Shiller (1989). I analyze the volatility by analyzing the variance of the change in market value over the auction from time t_{-1} to time t.

Lemma 3.3: *Suppose $L = A$, the variance of the predicting error*

$$\text{var}\left(\tilde{x} - R\,\tilde{S} \mid \tilde{y}^* = y^*\right) = \Gamma - R^2\,\text{var}\left(\tilde{S} \mid \tilde{y}^* = y^*\right), \tag{5.1}$$

where the volatility of the market price

$$\text{(5.2)} \qquad \operatorname{var}\left(\tilde{S} \mid \tilde{y}^* = y^*\right) = \left(\frac{\Gamma}{R}\right)^2 \frac{N + M\alpha}{N\Gamma + (M+1)(\Gamma + \eta)\alpha}.$$

The volatility is limited by the variance bound

$$\text{(5.3)} \qquad \operatorname{var}\left(\tilde{S} \mid \tilde{y}^* = y^*\right) \leq \operatorname{var}\left(\tilde{S}^\bullet \mid \tilde{y}^* = y^*\right) = \left(\frac{\Gamma}{R}\right)^2 \frac{\left(\frac{\varepsilon}{\eta} + N\right)\left(\left(\frac{\varepsilon}{\eta} + N\right)\Gamma + \varepsilon\right)}{\left(N\Gamma + (\Gamma + \eta)\frac{\varepsilon}{\eta}\right)^2} \leq \frac{\Gamma}{R^2},$$

where $var(S^\bullet \mid y^*=y^*)$ *is the volatility of the corresponding sufficient informational statistic. If* $L = \boldsymbol{B}$, *then* μ *replaces* M.

Proof: See appendix B.

The variance of the predicting error is a measure of the uncertainty faced by uninformed traders planning to trade in security k at the batch auction at time t. It equals the total uncertainty minus the uncertainty revealed by the market price, or equivalently

$$\text{(5.4)} \quad \underbrace{\operatorname{var}\left(\tilde{x} - R\,\tilde{S} \mid \tilde{y}^* = y^*\right)}_{\substack{\text{Uncertainty faced by traders with}\\ \text{access only to public information}}} = \underbrace{\Gamma - R^2 \operatorname{var}\left(\tilde{S}^\bullet \mid \tilde{y}^* = y^*\right)}_{\substack{\text{Uncertainty faced by fully}\\ \text{informed traders}}} + \underbrace{R^2\left(\operatorname{var}\left(\tilde{S}^\bullet \mid \tilde{y}^* = y^*\right) - \operatorname{var}\left(\tilde{S} \mid \tilde{y}^* = y^*\right)\right)}_{\substack{\text{Additional uncertainty faced by traders}\\ \text{with no access to non-public information}}}.$$

The uncertainty faced by uninformed traders decreases if the superiorly informed speculators hold back more information by trading less aggressively. Observe from (5.2) that the uncertainty is not influenced by so called "popular models" (see Shiller (1989), page 3) because the variance of the predicting error is independent of σ. This implies that the informed and risk neutral speculators scale up their trades proportionally if investors with sentiment strategies are expected to increase their trades, and they thereby neutralize the effect. The first term in (5.4) may be interpreted as the difference between perfect information and available information whereas the final term may by be interpreted as follows:

$$\underbrace{\mathrm{var}\left(\tilde{S}^{*} \mid \tilde{y}^{*}=y^{*}\right) - \mathrm{var}\left(\tilde{S} \mid \tilde{y}^{*}=y^{*}\right)}_{\substack{\text{Information hold back from} \\ \text{the market by informed speculators} \\ \text{acting strategically}}} = \underbrace{\mathrm{var}\left(\tilde{S}^{*} \mid \tilde{y}^{*}=y^{*}\right)}_{\substack{\text{Total amount of} \\ \text{private information}}} - \underbrace{\mathrm{var}\left(\tilde{S} \mid \tilde{y}^{*}=y^{*}\right)}_{\substack{\text{Information revealed} \\ \text{by the trades of} \\ \text{informed speculators}}}. \tag{5.5}$$

Consequently, the variance of the market price measures the amount of information that is revealed about security k at time t (see Foster and Viswanathan (1990), pages 602 - 605), and it is easy to show that the volatility is proportional to the informativeness of the price as measured by (5.10).

Proposition 3.7: *The volatility of the market price increases with the number of corporate insiders trading in the securities market:*

$$\frac{d\,\mathrm{var}\left(\tilde{S} \mid \tilde{y}^{*}=y^{*}\right)}{d\mu} = \left(\frac{\Gamma}{R}\right)^{2} \frac{(\Gamma + \eta)\,\alpha^{2}}{\left[N\Gamma + (\mu + 1)(\Gamma + \eta)\,\alpha\right]^{2}} > 0. \tag{5.6}$$

If $\eta > 0$, $var(S(\mu = 0) / y^*=y^*) < var(S(\mu \to \infty) / y^*=y^*) < \Gamma / R^2$. However, if $\eta = 0$, $var(S(\mu \to \infty) / y^*=y^*) = \Gamma / R^2$.

Proof: I use (5.2) and the derivative follows without any difficulties. It is possible to show that $d^2\, var(S \mid y^*=y^*) / d\, \mu^2 < 0$, meaning that $var(S(\mu) \mid y^*=y^*)$ is increasing and strictly concave. The next step is to find the limits when the number of corporate insiders approaches zero or infinity:

$$\mathrm{var}\left(\tilde{S}(\mu = 0) \mid \tilde{y}^{*}=y^{*}\right) = \left(\frac{\Gamma}{R}\right)^{2} \frac{N}{(N + 1)\Gamma + 2\varepsilon}, \text{ and} \tag{5.7}$$

$$\mathrm{var}\left(\tilde{S}(\mu \to \infty) \mid \tilde{y}^{*}=y^{*}\right) = \left(\frac{\Gamma}{R}\right)^{2} \frac{N + \dfrac{\Gamma + 2\varepsilon}{\eta}}{N\Gamma + \dfrac{(\Gamma + 2\varepsilon)(\Gamma + \eta)}{\eta}}. \tag{5.8}$$

By comparing the two limits, we observe that (5.7) is smaller than (5.8). Finally, if $\eta = 0$, $var(S(\mu \to \infty) \mid$

y*=y*) = Γ / R^2. Q.E.D.

The volatility of the market price increases with the supply of corporate insiders. This is because more (or better) information is communicated via trading into the net order flow and thereby into the transaction price. New information changes the expectations of the intermediaries which again creates variability in the price system.

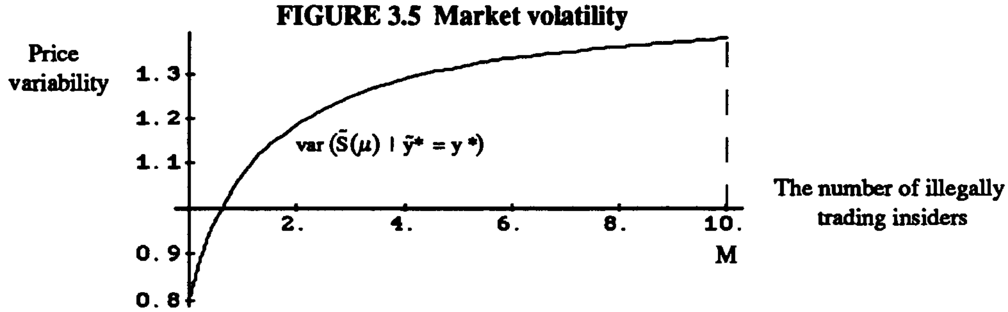
Corollary 3.6: *Suppose L changes from **A** to **B**, then*

(5.9) $$\mathrm{var}\left(\tilde{S}(\mu) \mid \tilde{y}^* = y^*\right) \le \mathrm{var}\left(\tilde{S}(M) \mid \tilde{y}^* = y^*\right).$$

Proof: This follows from (5.6) since $\mu \le M$. Q.E.D.

The market prices are more volatile if insider trading is permitted. Such a conclusion is consistent with the results in Leland (1992), page 871. Figure 3.5 illustrates.

FIGURE 3.5 Market volatility



This example indicates that if $\mu \to \infty$, var(S | y*=y*) = 1.455 < var(S• | y*=y*) = 1.600 < Γ = 2.000. On the contrary, if μ = 0, var(S | y*=y*) = 0.800. This means that if insider trading is prohibited and effectively enforced, the informed traders hold back 50% of the total information whereas they hold back 14% when insider trading is allowed.

5.2 Market efficiency

Assuming price taking behavior among a limited number of risk neutral market makers leads to no expected profits by dealing on public information in the dealership market. This suggests that the price system is at least semi-strong efficient. In addition to public information, the price system will reflect some of the information acquired by the superiorly informed speculators. This is because the speculators affect the net order flow through their buy and sell orders.

Lemma 3.4: *Suppose $L = A$, then a measure of the amount of private information reflected in the equilibrium price of security k at time t is*

$$\Psi = \frac{1}{\operatorname{var}\left(\tilde{x} \mid \tilde{S}, \tilde{y}^* = y^*\right)} = \frac{1}{\Gamma} + \frac{N}{\Gamma + 2\varepsilon} + \frac{M}{\Gamma + (M+1)\eta}, \tag{5.10}$$

where

$$\Psi \le \Psi^* = \frac{1}{\Gamma} + \frac{N}{\varepsilon} + \frac{1}{\eta}. \tag{5.11}$$

If, on the other hand, $L = B$, then μ replaces M.

<u>Proof</u>: See appendix C.

The first term in (5.10) is the precision of the future value of the security given public information, and if there are no informed traders, the market price reflects only public information. The second term reflects the private information transmitted into the price by the trades of smart money investors, and the final term reflects the privileged information communicated into the price by the trades of corporate managers. If $\Psi = \Psi^*$, the price system is a sufficient informational statistic.

Proposition 3.8: *The informativeness of the price system increases with the number of insiders trading illegally:*

$$\frac{d\Psi}{d\mu} = \frac{\Gamma + \eta}{\left[\Gamma + (\mu + 1)\eta\right]^2} > 0. \tag{5.12}$$

If $\eta > 0$, $\Psi(\mu = 0) < \Psi(\mu \to \infty) < \infty$. However, if $\eta = 0$, $\Psi(\mu \to \infty) \to \infty$.

Proof: I use (5.10) where μ replaces M and (5.12) is its derivative with respect to μ. Note that $d^2 \Psi / d \mu^2 < 0$, implying that $\Psi(\mu)$ is increasing and strictly concave. The limits are

$$\Psi(\mu = 0) = \frac{1}{\Gamma} + \frac{N}{\Gamma + 2\varepsilon}, \text{ and} \tag{5.13}$$

$$\Psi(\mu \to \infty) = \frac{1}{\Gamma} + \frac{N}{\Gamma + 2\varepsilon} + \frac{1}{\eta}. \tag{5.14}$$

Clearly, the market efficiency is higher when there are infinitely many insider than when there are none. If $\eta = 0$, then, according to (5.14), $\Psi(\mu \to \infty) \to \infty$. Q.E.D.

The price informativeness increases with the number of corporate insiders as the order flow becomes more informative due to less coordination among the informed speculators when trying to limit their trading intensities.

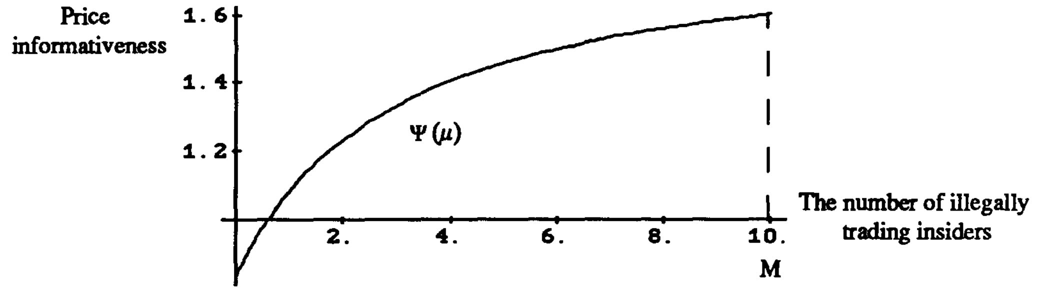
Corollary 3.7: *Suppose L changes from **A** to **B**, then*

$$\Psi(M) \geq \Psi(\mu). \tag{5.15}$$

Proof: This follows from (5.12) since $\mu \leq M$. Q.E.D.

This proposition suggests that if the supply of smart money investors is fixed, the price efficiency is higher if the corporate insiders are allowed to trade. Insider trading reduces the uncertainty about the liquidity value of the speculative asset by a premature resolution of uncertainty at the time of trade; see, e.g., Leland (1992), page 871 for a similar result. Figure 3.6 illustrates.

FIGURE 3.6 Information content in the market price



In this example, $\Psi(\mu = 0) = 0.833$ and $\Psi(\mu \to \infty) = 1.833 < \Psi^{*} = 2.500$. This suggests that the price is partially revealing for all μ.

3.6 ENDOGENOUS SUPPLY OF MARKET PROFESSIONALS

In this section, the supply of market professionals is determined as part of the equilibrium. This is done simply by imposing a competition constraint on their expected profit, making N an endogenous variable. I concentrate on what happens to the trading intensities of the superiorly informed traders, the price sensitivity set by the market makers, and the informativeness of the transaction price when the supply of corporate insiders changes due to an exogenous change in the insider trading law. The welfare effects are analyzed in section 4.5, and the case where the liquidity traders are in elastic supply is analyzed in sections 4.6 - 4.7.

Lemma 3.5: *If the supply of market professionals is elastic, the equilibrium supply, denoted N^{*}, is determined by the competition constraint*

$$E\left[\tilde{\pi}_n^N \mid \tilde{y}^* = y^*\right] - C = 0, \tag{6.1}$$

where $C \geq 0$ is the individual cost of acquiring a private signal y_n. The expected revenue generated by using the signal is

$$(6.2) \qquad E\left[\tilde{\pi}_n^N \mid \tilde{y}^* = y^*\right] = \frac{(\Gamma + \varepsilon)\,\Gamma}{N^*\,\Gamma + (M + 1)(\Gamma + \eta)\,\alpha}\sqrt{\frac{\sigma}{N^*\,(\Gamma + \varepsilon) + M(\Gamma + \eta)\,\alpha^2}}.$$

If insider trading is prohibited, then μ replaces M.

Proof: The assumed equilibrium condition (6.1) leads to zero expected profit in the securities industry, and (6.2) is derived in chapter 4 (see (4.2.3)). Q.E.D.

This means that market professional $n \in \{1, 2, ..., N\}$ enters into the securities industry if his or her expected profit from trading on the signal y_n exceeds the cost of acquiring the private signal. This way of endogenously determining the information acquisition is also chosen by , for instance, Admati and Pfleiderer (1988), pages 14 - 21.

It turns out that it is possible but not very convenient to obtain a closed form solution for the optimal supply (as N^* is characterized by a third order equation), but it is straightforward to find it numerically. This is done in figure 3.7 below.

Proposition 3.9: *The equilibrium supply of professionals N^* depends on the exogenously determined supply of corporate insiders:*

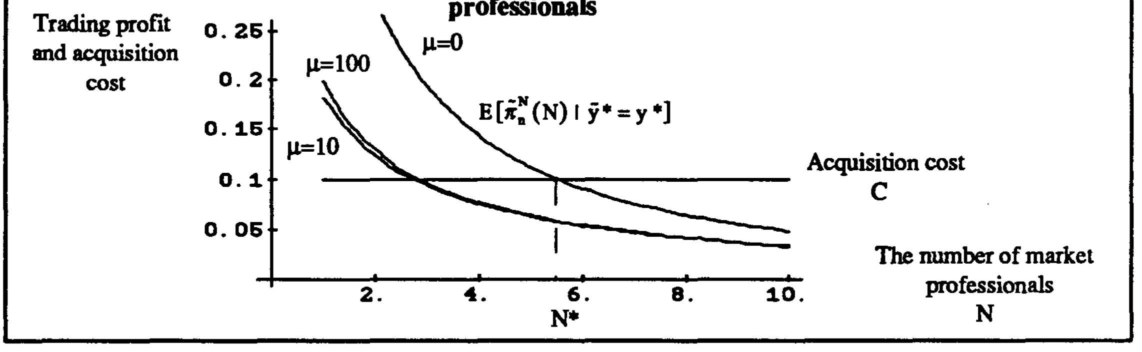
$$(6.3) \qquad \mathrm{Sgn}\left(\frac{dN^*}{d\mu}\right) = -\,\mathrm{Sgn}\left[\frac{\Gamma}{N^*\,\Gamma + (\mu + 1)(\Gamma + \eta)\,\alpha} + \frac{\alpha\left(\Gamma + (1 - \mu)\,\eta\right)}{N^*\,(\Gamma + \varepsilon) + \mu(\Gamma + \eta)\,\alpha^2}\right].$$

If $\eta = 0$, then the effect is negative for all μ.

Proof: I use the implicit-function rule (see, e.g., Chiang (1984), page 208): $d N^* / d\mu = -(d\,[E[\pi^N_n \mid y^*=y^*] - C] / d\mu) / (d\,[E[\pi^N_n \mid y^*=y^*] - C] / d N^*)$. Then I use (6.2) and find that $d\,[E[\pi^N_n \mid y^*=y^*] - C] / d\mu$ has the sign determined by the right hand side of (6.3). Clearly, $d\,[E[\pi^N_n \mid y^*=y^*] - C] / d\,N^* < 0$. This means that $\mathrm{Sgn}(d\,N^* / d\,\mu) = -\,\mathrm{Sgn}(d\,[E[\pi^N_n \mid y^*=y^*] - C] / d\,\mu) / (d\,[E[\pi^N_n \mid y^*=y^*] - C] / d\,N^*) = \mathrm{Sgn}(d\,[E[\pi^N_n \mid y^*=y^*] - C] / d\,\mu)$ which equals the right hand side of (6.3). If $\eta = 0$, then α is independent of μ and $d\,[E[\pi^N_n \mid y^*=y^*] - C] / d\,\mu < 0$. This implies that $d\,N^* / d\,\mu$ is negative for all μ. Q.E.D.

This indicates that if the supply of corporate insiders increases (to $\mu < \mu_\beta$), the number of market professionals is reduced. Thus, the insiders may squeeze the professionals out of the market which may end up in the equilibrium given by corollary 2.1 if the individual cost of acquiring information is high. Figure 3.7 illustrates using the numerical values given in table 3.3.

FIGURE 3.7 Equilibrium supply of market professionals



The cost of acquiring information is independent of μ, and, according to (6.2), $d\,E[\pi^N_n(N) \mid y^*=y^*] / d\,N < 0$. In this example, if $\mu = 0$, the equilibrium supply equals 5.516 (ignoring the integer problem). Because of increased competition from corporate insiders, it becomes less profitable for the professionals to trade, and the expected revenue shifts downward. This leads to fewer smart money investors in the market (if, e.g., $\mu = 10$, $N^* = 2.394$). Note, however, that the revenue function shifts outward if μ increases from, e.g., 10 to 100 (and N^* shifts from 2.394 to 2.737).

Corollary 3.8: *If L changes from A to B in a security where M is small, the securities industry expands. Thus,* (6.4) $$\Delta N^* = N^*(\mu) - N^*(M) > 0.$$

If M is large, the effect on the size of the securities industry depends on the enforcement of the insider trading regulations.

Proof: This follows from (6.3) and the assumption that $\mu \leq M$. Q.E.D.

This suggests that if L changes from **A** to **B**, the equilibrium supply of market professionals tends to increase because of less competition among the informed speculators. If corporate insiders are trading, we might say that the professionals "lose confidence" in the securities market and therefore leave. In reality they are forced out because of greater competition from other informed speculators, and it has nothing to do with psychology.

6.1 Intensity of trade

I define the number of market professionals needed to keep their trading intensity unchanged from L = A to L = B or *vice versa*:

(6.5) $$N_{\Delta\beta=0} = N^*(M) + \Delta N_{\Delta\beta=0},$$

where $\Delta N_{\Delta\beta=0}$ is the needed entries of smart money investors to keep $\beta(M) = \beta(\mu)$. The next proposition gives its closed form.

Lemma 3.6: *The needed entries of market professionals to keep their trading intensity unchanged when L shifts from **A** to **B** is*

(6.6) $$\Delta N_{\Delta\beta=0} = \frac{\Gamma + \eta}{\Gamma + \varepsilon}\left(M\,\alpha^2(M) - \mu\,\alpha^2(\mu)\right).$$

Proof: I use (2.3.3) and set it equal to (2.3.3) where μ replaces M, and solve for ΔN. The needed inflow follows straight away. Q.E.D.

The needed entries of market professionals depends on the change in the number of corporate insiders and on the change in the insiders' trading response relative to the trading response of market professionals.

Corollary 3.9: *Suppose $\Delta N_{\Delta\beta=0} < \Delta N^*$, then*

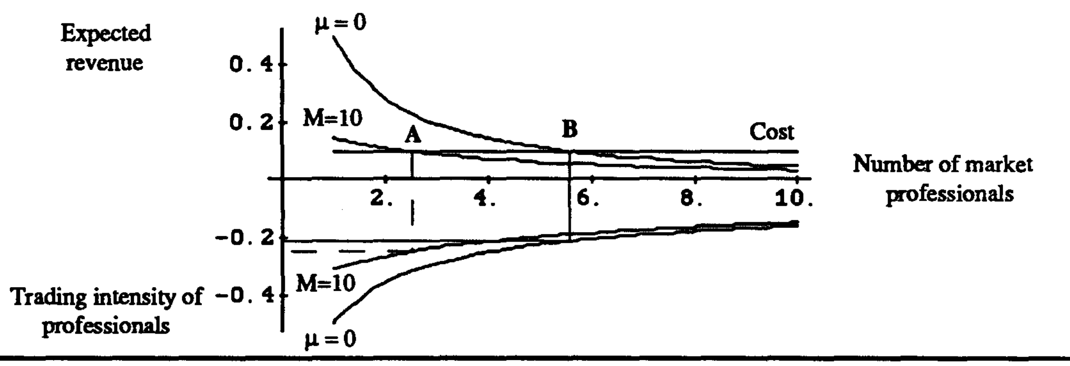
$$\beta(\mu) < \beta(M). \tag{6.7}$$

Otherwise the opposite happens.

<u>Proof</u>: This follows by definition. Q.E.D.

On a stock market exchange where privately informed outsiders are very sensitive towards the rule governing insider trading, their intensity of trade decreases if insider trading is prohibited by the stock market regulators. This is because the existing smart money investors face harder competition from entering traders than from the full supply of corporate insiders. Figure 3.8 illustrates (note that the trading intensities are measured negatively).

FIGURE 3.8 Optimal trading intensity



If insider trading is prohibited (meaning that the equilibrium shifts from A to B in the figure), the expected revenue as a function of the equilibrium number of smart money investors shifts outward, and the professionals' trading intensity shifts downward in the figure. We observe that $\Delta N^* = 3.121 > \Delta N_{\Delta\beta=0} = 1.524$ which gives $\beta(\mu) = 0.213 < \beta(M) = 0.323$ as proposed above. For instance, if M = 1, the opposite happens. In this case $\beta(\mu) = 0.213 > \beta(M) = 0.211$ since $\Delta N^* = 1.581 < \Delta N_{\Delta\beta=0} = 1.687$.

6.2 Price sensitivity

I define the number of market professionals needed to keep the price sensitivity unchanged by the regulatory shift from L = **A** to L = **B**:

(6.8) $$N_{\Delta\lambda=0} = N^*(M) + \Delta N_{\Delta\lambda=0},$$

where $\Delta N_{\Delta\lambda=0}$ is the needed entries of informed smart money investors to keep $\lambda(M) = \lambda(\mu)$. There is no closed form.

Corollary 3.10: *If $\Delta N_{\Delta\lambda=0} > \Delta N^*$, then*

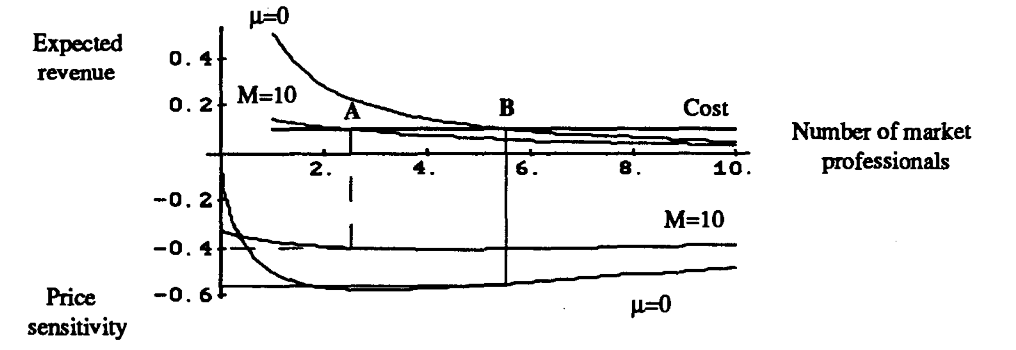
(6.9) $$\lambda(\mu) > \lambda(M).$$

Otherwise the opposite happens.

Proof: This follows by definition. Q.E.D.

Figure 3.9 illustrates using the numerical values given in table 3.3 (note that the price sensitivity is measured negatively).

FIGURE 3.9 Price sensitivity



The price sensitivity is a unimodal function of the number of market professionals, increasing for small N and decreasing for large. As the number of market professionals grows toward infinity, the price sensitivity converges towards zero. This is because the professionals observe diverse private information, implying that the equilibrium order flow reveals approximately all privately acquired information for very large N. There are no adverse selection problems in fully revealing equilibria, allowing the market makers to hold a very liquid market.

We see that $\Delta N_{\Delta\lambda=0} = 16.221 > \Delta N^* = 3.121$ and $\lambda(M) = 0.392 < \lambda(\mu) = 0.552$. This is consistent with (6.9) above. The opposite happens, e.g., if $M = 1$. In this case, $\lambda(M) = 0.562 > \lambda(\mu) = 0.552$ because $\Delta N^* = 1.581 > \Delta N_{\Delta\lambda=0} = 0.827$.

6.3 Market efficiency

I define the number of market professionals needed to keep the price efficiency unchanged over the regulatory shift from L = **A** to L = **B**:

$$N_{\Delta\Psi=0} = N^*(M) + \Delta N_{\Delta\Psi=0}, \tag{6.10}$$

where the last term is the entries of market professionals needed to keep the efficiency unchanged. Its closed form follows.

Lemma 3.7: The needed entries of privately informed market professionals to keep the price informativeness *unchanged is*

(6.11) $$\Delta N_{\Delta\Psi=0} = M\,\alpha(M) - \mu\,\alpha(\mu).$$

Proof: I use (5.7) and set $\Psi(M) = \Psi(\mu)$ and obtain the difference between $N_{\Delta\Psi=0}$ - $N^*(M)$ given by (6.11). Q.E.D.

In this way, the needed inflow of market professionals depends on the change in the number of corporate insiders and on the change in the corporate insiders' trading response relative to the trading response of smart money investors.

Corollary 3.12: *If $\Delta N_{\Delta\Psi=0} > \Delta N^*$, then*

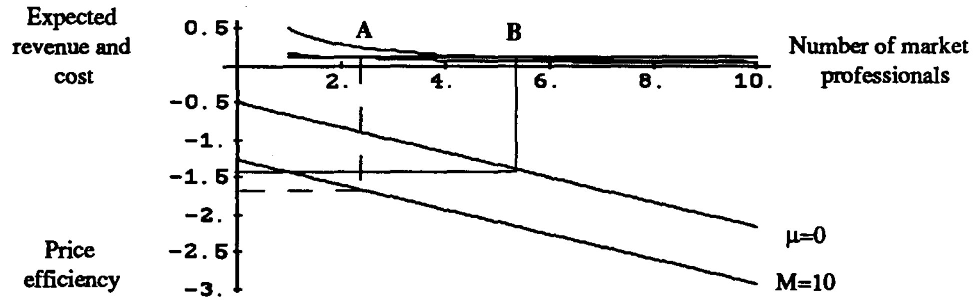
(6.12) $$\Psi(M) > \Psi(\mu).$$

Otherwise the opposite happens.

Proof: This follows by definition. Q.E.D.

This is consistent with Fishman and Hagerty (1992) who observe that market efficiency decreases if insider trading is prohibited in a securities market where the supply of market professionals is very elastic; see their proposition 1 on page 111. Figure 3.10 illustrates the opposite case (note that the price efficiency is measured negatively) as is always the case in a market with fixed supply.

FIGURE 3.10 Market efficiency



The price informativeness is a linear function in N. If L changes from A to B, then $\Delta N^* = 3.121 < \Delta N \Delta\Psi{=}0 = 4.615$ and $\Psi(M) = 1.668 > \Psi(\mu) = 1.419$. If M = 1, the opposite happens. In this case, $\Psi(M) = 1.406 < \Psi(\mu) = 1.419$ because $\Delta N^* = 1.581 > \Delta N_{\Delta\Psi=0} = 1.500$ (see also figure 1 on page 113 in Fishman and Hagerty (1992)).

3.7 SHORT SUMMARY OF MAJOR CONCLUSIONS

I have shown that insider trading may affect the properties of the equilibrium characterized by lemma 2.1 where the properties are the trading intensities of rational speculators, the price sensitivity, the equilibrium bid ask spread, the market depth, the expected trading volume, the market volatility, and the informativeness of the transaction price.

- If the enforcement of the law prohibiting insider trading is inadequate, the most aggressive trader need not to be a corporate insider, but can equally well be an outsider trading legally on privately acquired information. Nonetheless, if insider trading is prohibited, both the market professionals and the insiders tempted to trade illegally tend to trade harder than in an otherwise identical market where insider trading is allowed.
- Insider trading tends to reduce the price sensitivity and thereby the equilibrium bid ask spread. This happens even if the number of corporate insiders is large and the insider trading law is effectively enforced by the stock market regulators. However, the opposite tends to happen if the supply of corporate insiders is reduced from approximately one to zero.
- If insider trading is allowed, the liquidity of the market, measured by both its depth and its expected

trading volume, tends to be higher. This may happen even if the control authorities are very effective catching corporate insiders who are trading illegally. However, the depth tends to be lower if there is a monopolistic insider.

- The volatility of the transaction price and the market efficiency are higher when the corporate insiders are free to trade than in a regulated market where insider trading is prohibited by the stock market regulators.

The next chapter analyzes the effects of insider trading on the welfare of all participants, again using the stock market equilibrium characterized by lemma 2.1. In chapter 7 - 8, the properties of the equilibrium are analyzed under slightly different market conditions by taking into account risk aversion, hedging demand, and market power in the broker - dealership market.

APPENDICES

I derive measures of the expected trading volume, the volatility of the transaction price, and the price informativeness. All proofs are based on lemma 2.1. The last appendix presents the numerical values used in the example.

Appendix A Proof of lemma 3.2

This appendix draws on Admati and Pfleiderer (1988), pages 13 - 16. They measure the total expected trading volume as the sum of the expected trading volume from the informed speculators, the liquidity traders, and the market makers:

$$\text{(A1)} \qquad E\left[\tilde{V} \mid \tilde{y}^* = y^*\right] = \sqrt{\operatorname{var}\left(\sum_{n=1}^{N} \tilde{\theta}_n \mid \tilde{y}^* = y^*\right)} + \sqrt{\operatorname{var}\left(\sum_{m=1}^{M} \tilde{\Delta}_m \mid \tilde{y}^* = y^*\right)} + \sqrt{\operatorname{var}(\tilde{u} \mid \tilde{y}^* = y^*)} + \sqrt{\operatorname{var}(\tilde{z} \mid \tilde{y}^* = y^*)}.$$

Then I insert the trading strategies given by (2.3.1) and (2.3.2) and the net order flow given (2.A31). The result is

$$\text{(A2)}\; E\left[\tilde{V} \mid \tilde{y}^* = y^*\right] = \beta\sqrt{N(N\Gamma+\varepsilon)} + M\alpha\beta\sqrt{\Gamma+\eta} + \sqrt{\sigma} + \sqrt{\beta^2\begin{bmatrix}(N + M\alpha)^2\,\Gamma + \\ N\varepsilon + M^2\alpha^2\eta\end{bmatrix} + \sigma}.$$

The final step is to insert the trading intensity of market professionals given by (2.3.3). I yield (4.3) after some straightforward calculations. This completes the proof of lemma 3.2.

Appendix B Proof of lemma 3.3

The volatility measures the variability of the transaction price from time t_{-1} (i.e., just before time t) to time t. The transaction price is given by (2.3.7) and its variance equals

$$\text{(B1)} \qquad \mathrm{var}\left(\tilde{S} \mid \tilde{y}^* = y^*\right) = \left(\frac{\lambda}{R}\right)^2 \mathrm{var}(\tilde{z} \mid \tilde{y}^* = y^*).$$

I use the order flow given by (2.A31) and get

$$\text{(B2)} \qquad \mathrm{var}\left(\tilde{S} \mid \tilde{y}^* = y^*\right) = \left(\frac{\lambda}{R}\right)^2 \left\{\beta^2\left[(N + M\alpha)^2\,\Gamma + N\varepsilon + M^2\alpha^2\eta\right] + \sigma\right\}.$$

The next step is to insert the trading intensity of market professionals given by (2.3.3) and the price sensitivity given by (2.3.8), and the result of this operation is given by (5.2) and it follows without any difficulties. If the equilibrium is fully revealing, the price would equal the price in a market where the market makers observe all available information. Thus,

$$\text{(B3)} \qquad \tilde{S}^* = \frac{1}{R}\,E[\tilde{x} \mid \tilde{y}, \tilde{y}_1, \ldots, \tilde{y}_N, \tilde{y}^* = y^*],$$

or (by the rule of conditional expectation)

$$\text{(B4)}\quad \tilde{S}^{*} = \frac{1}{R}\left\{\frac{1}{N\Gamma + (\Gamma+\eta)\dfrac{\varepsilon}{\eta}}\left[\varepsilon\, E[\tilde{x} \mid \tilde{y}^{*}=y^{*}] + \Gamma\left(\frac{\varepsilon}{\eta}\tilde{y} + \tilde{y}_1 + \tilde{y}_2 + \ldots + \tilde{y}_N\right)\right]\right\}.$$

Notice that

$$\text{(B5)}\qquad \lim_{N\to\infty} \tilde{S}^{*}(N) = \frac{1}{R}\,\tilde{x}.$$

If there are infinitely many traders observing diverse information, the price equals the present value of the underlying fundamental. This is not the case if there instead are infinitely many traders observing common information. The variance of the sufficient statistic follows directly from (B4) and is given in (5.3). This completes the proof of lemma 3.3.

Appendix C Proof of lemma 3.4

The efficiency of the market is measured by $\Psi = 1 / \mathrm{var}(x \mid S, y^{*}=y^{*})$ where the conditional variance reflects the uncertainty after observing the current transaction price. If the price reveals information about the future value, the conditional variance is reduced (from $\mathrm{var}(x \mid y^{*}=y^{*})$ to $\mathrm{var}(x \mid S, y^{*}=y^{*})$, and consequently the efficiency increases. This is the case because

$$\text{(C1)}\qquad \mathrm{var}\left(\tilde{x} \mid \tilde{S}, \tilde{y}^{*}=y^{*}\right) = \Gamma - \lambda\, \mathrm{cov}(\tilde{x}, \tilde{z} \mid \tilde{y}^{*}=y^{*}) = \Gamma\left(1 - \beta\lambda\,(N + M\alpha)\right).$$

I insert (2.3.3) and (2.3.8) and yield

$$\text{(C2)}\qquad \mathrm{var}\left(\tilde{x} \mid \tilde{S}, \tilde{y}^{*}=y^{*}\right) = \frac{\Gamma(\Gamma + 2\varepsilon)}{N\Gamma + (M+1)(\Gamma+\eta)\,\alpha}.$$

The inverse is given by (5.10) and measures the informativeness of the market price. If the price is fully revealing, we could condition directly on the signals:

(C3) $$\operatorname{var}(\tilde{x} \mid \tilde{y}_1, \ldots, \tilde{y}_2, \tilde{y}, \tilde{y}^* = y^*) = \frac{\Gamma \varepsilon}{N\Gamma + (\Gamma + \eta)\frac{\varepsilon}{\eta}}.$$

The inverse is given by (5.11). This completes the proof of lemma 3.4.

Appendix D Example

Table 3.3 gives the numerical values used in the figures to illustrate the properties of the securities market equilibrium.

TABLE 3.3:			Numerical values					
Γ	=	2,	σ	=	1,	N	=	2,
η	=	1,	R	=	1,	M	=	10,
ε	=	2,	C	=	0.1,	μ	$\in$	$\{0, 1, \ldots, 10\}$,
						Q	$\in$	$\{1, 2, \ldots\}$.

I have assumed that there are only two market professionals present in the securities market, because if, e.g., N = 200 some of the endogenously determined parameters become relatively small without, of course, altering any of the conclusions.

REFERENCES

Admati, A., and P. Pfleiderer, 1988, "A Theory of Intraday Patterns: Volume and Price Variability," Review of Financial Studies, 3 - 40.

Black, F. , 1971, "Toward a Fully Automated Stock Exchange, Part I," Financial Analysts Journal, 28 - 35 and 44.

Chiang, A. C., 1984, "Fundamental Methods of Mathematical Economics," McGraw-Hill.

Fishman, M. J., and K. M. Hagerty, 1992, "Insider Trading and the Efficiency of Stock Prices," Rand Journal of Economics, 106 - 122.

Foster, F. D., and S. Viswanathan, 1990, "A Theory of the Interday Variations in Volume, Variance, and Trading Costs in Security Markets," Review of Financial Studies, 593 - 624.

Glosten, L. R., and P. Milgrom, 1985, "Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders," Journal of Financial Economics, 71 - 100.

King, M., and A. Röell, 1988, "Insider Trading," Economic Policy, 165 - 187.

Kyle, A. S., 1985, "Continuous Auctions and Insider Trading," Econometrica, 1315 - 1335.

Leland, H. E., 1992, "Insider Trading: Should it be Prohibited?" Journal of Political Economy, 859 - 887.

Miller, M. H., 1991, "Financial Innovations and Market Volatility," Blackwell.

Shiller, R., 1989, "Market Volatility," MIT Press.

CHAPTER 4

WELFARE EFFECTS CAUSED BY A CHANGING SUPPLY OF CORPORATE INSIDERS

First draft: October 1990,

Current revision: November 1992.

ABSTRACT

Insider trading is shown to affect the expected profit of security traders such as market professionals and liquidity traders. I identify two effects; one caused by competition and the other by adverse selection. First, if the trader is motivated by liquidity events, the competition in exploiting superior information is zero. If, on the other hand, the trader is motivated by privately acquired information, the competition increases with the supply of corporate insiders, leading to less expected profit. Secondly, the adverse selection effect works indirectly through the problem of differentiating the informed from the uninformed, faced by the price setting market makers. If one insider enters, the adverse selection problem is increased. The result is a negative effect on the expected profit of both the liquidity traders and the market professionals. However, if the supply expands further, the adverse selection decreases due to competition among the informed. The result is a positive effect on the expected profits of all traders. In this way, the total effect is a trade-off between these effects. I conclude that the market professionals tend to prefer insider trading prohibited, whereas the liquidity traders tend to prefer insider trading allowed. Nevertheless, they tend to agree that the worst case is to have an insider trading law which is not adequately enforced by the stock market regulators.

4.1 INTRODUCTION

This chapter analyzes the welfare effects caused by insider trading and its regulation on the stylized stock market exchange characterized by lemma 2.1. On that exchange, I have assumed that all participants are risk neutral. It means that the welfare effects caused by insider trading are completely measured by its effects on expected profit. My analysis shows that insider trading affects the expected profit of all participants. However, it turns out that the welfare effects may not be as unique as many have thought. For instance, the financial market design turns out to be critical for the conclusion.

Welfare of liquidity traders

I take the previous literature on financial markets with asymmetric information as a starting point for further research on insider trading. Admati and Pfleiderer (1988) observe that

> "...as long as there is at least one informed trader, the introduction of more informed traders generally intensifies the forces leading to the concentration of trading by discretionary liquidity traders. This is because informed traders compete with each other, and this typically improves the welfare of liquidity traders." [1]

Their findings might be interpreted to suggest that if insider trading is prohibited and effectively enforced, the trading cost of noise or liquidity traders is minimized. But as long as there is at least one corporate insider, the trading cost decreases with further supply. Consequently, if the welfare of liquidity traders is a primary concern of stock market regulators, it is optimal to prohibit insider trading and enforce the law so that there are no illegally trading insiders. If, on the other hand, it is costly to enforce the law leading to illegal trading, the liquidity traders may somewhat surprisingly prefer to trade in periods, securities, and markets which allow intensive insider trading. This is because liquidity traders are better off if they trade together with legally trading, rather than together with illegally trading insiders. The reason is that the former have less market power.

---

[1] See page 5 in their article.

I find that the tendency towards concentration is even stronger than previously suggested. As long as there is at least one outsider trading on privately acquired information, the liquidity traders tend to concentrate their trades in markets, securities, and periods with intensive insider trading. The reason is that there always are other informed traders such as security analysts who are impossible to get rid of by regulations. As the basis for their trades such professionals use privately acquired information from outside sources, and increase thereby the adverse selection problem faced by the intermediaries. This means that insider trading on correlated information may reduce the overall adverse selection problem, because an additional supply of informed traders intensifies competition, leading to more information being revealed through the influence of corporate insiders on the equilibrium order flow.

Welfare of market professionals

My model has an additional advantage relative to most previous models (including Admati and Pfleiderer (1988)). It is possible to analyze the effects of insider trading regulations on the welfare of other privately informed speculators. Another model with this feature is Fishman and Hagerty (1992), who divide the informed speculators into one corporate insider and several market professionals. Notice that the competitive outsiders in, e.g., Leland (1992) are not speculators but arbitrageurs because they trade on public information generated by observing the equilibrium price (see chapter 8 for further comments on the distinction between speculators and arbitrageurs).

I use the securities market model characterized by lemma 2.1 where there is a limited number of market professionals competing with a limited number of corporate insiders. Unlike in Fishman and Hagerty (1992), my framework allows competition among the corporate insiders, leading to new and interesting results relevant for the insider trading debate. If the corporate insiders are allowed to trade on inside information, the market professionals face harder competition. This means that they prefer to trade alone, without the company of other informed traders, but of course together with as many liquidity traders as possible. The reason is that less competition gives the market professionals a higher price manipulative power, and therefore higher expected profits. Nevertheless, I can identify two situations where the market professionals may actually prefer to trade together with the corporate insiders:

- If the cost of enforcing the law is high, there would be corporate insiders trading illegally (see sections 5.4 - 5.5). The illegal trading insiders have a larger market power than would be the case in an unregulated market. This again may lead to harder competition and less expected profits to the market professionals.
- Suppose the supply of market professionals is very elastic towards the rule governing insider trading, then if insider trading is prohibited, the influx of new professionals may be so large that the market power of existing market professionals actually decreases. This makes the existing professionals worse off. This argument is not valid unless there is an inefficiency, causing fewer than optimal to enter into the security industry in markets allowing insider trading. If there are no such inefficiency, the market professionals expect to earn zero profit in both cases, and are therefore really indifferent towards the rule governing insider trading.

I conclude that the outside professionals may both vote against and in favor of a public law prohibiting insider trading. The conclusion depends, among other things, on the expected effectiveness of the enforcement supplied by the regulatory agency.

I ignore three important effects that we have to take into account if we are going to evaluate the desirability of insider trading in real financial markets: First, because I assume risk neutrality, I ignore changes in the possibilities of risk sharing (see chapter 7 - 8). Secondly, the market is assumed to be semi-strong efficient, suggesting that it is not possible to earn money on trading strategies based on public information. I am therefore really ignoring effects on the welfare of broker - arbitrageurs, simply by keeping them out of the securities market (see chapter 8). Finally, the economy has no production so possible incentive effects caused by insider trading are ignored (see chapters 5 - 6). Otherwise, it would make sense to evaluate the effects caused by insider trading on the welfare of current shareholders. These effects are one by one taken into account in chapters 5 - 8.

This chapter is structured as follows. The next section is technical and presents the expected profit of all individuals. Section three analyzes the effects of insider trading on the expected profit of both types of superiorly informed speculators, whereas section four analyzes the effects on the expected trading cost of publicly informed liquidity traders. I extend in section five to a corresponding securities market in which the supply of market professionals is elastic, and analyze what happens to the trading cost of the liquidity traders. Section six focuses on the optimal behavior of discretionary liquidity traders, and section seven analyzes the case where the liquidity traders for some reason "lose confidence" in a market in which the supply of corporate insiders increases. In section eight, I show that there might be a conflict of interest between informed and uninformed outsiders. Section nine gives a short summary of major conclusions. Formal proofs are given in the appendices.

4.2 EXPECTED PROFIT

This section gives the expected welfare of all participants by drawing on the securities market equilibrium characterized by lemma 2.1. In that market, the superiorly informed speculators trade because they have a desire, represented by a linear utility function, to make a profit as a higher realized profit allows a greater consumption. Perhaps the noise or liquidity traders have the same objective, but they possess no superior information when they determine their trading strategies. Maybe they are chasing trends? On the other side of the market, the market makers observe the net order flow, and use it trying to make a supernormal return. Table 4.1 presents the major components in the expected profits of these traders (see lemmas 4.1 - 4.2 and the appendices for further details).

TABLE 4.1:		**Expected profit**
$E\left[\sum_{d=0}^{D}\tilde{\pi}_d^D \mid \tilde{y}^* = y^*\right]$	:	$-\lambda \ \mathrm{var}(\tilde{u} \mid \tilde{y}^* = y^*)$
$+\ E\left[\sum_{n=1}^{N}\tilde{\pi}_n^N + \sum_{m=1}^{M}\tilde{\pi}_m^M \mid \tilde{y}^* = y^*\right]$	:	$\mathrm{cov}\left(\tilde{x},\ \sum_{n=1}^{N}\bar{\theta}_n + \sum_{m=1}^{M}\bar{\Delta}_m \mid \tilde{y}^* = y^*\right) - \lambda\ \mathrm{var}\left(\sum_{n=1}^{N}\theta_n + \sum_{m=1}^{M}\bar{\Delta}_m \mid \tilde{y}^* = y^*\right)$
$+\ E\left[\sum_{q=1}^{Q}\tilde{\pi}_q^Q \mid \tilde{y}^* = y^*\right]$	:	$\lambda\ \mathrm{var}(\tilde{z} \mid \tilde{y}^* = y^*) - \mathrm{cov}\left(\tilde{x},\ \sum_{n=1}^{N}\bar{\theta}_n + \sum_{m=1}^{M}\bar{\Delta}_m \mid \tilde{y}^* = y^*\right)$
= Sum expected profit	:	0

This table shows that the Q market makers who are dealing in security $k \in \{1, 2, ..., K\}$ at time $t \in \{0, 1, ..., T_k-1\}$ expect to earn a positive revenue which depends on the equilibrium bid ask spread and the trading volume (i.e., $ER_Q = \lambda \text{ var}(z \mid y^*=y^*)$). But they have to pay a cost due to adverse selection which is caused by the fact that informed speculators submit orders correlated with the future value of the security (i.e., $EC_Q = \text{cov}(x, z \mid y^*=y^*)$). On the demand side of the market, the M + N informed speculators expect to earn a positive revenue since their trading strategies are correlated with the future value of the security ($ER_{M+N} = \text{cov}(x, z \mid y^*=y^*)$), but they have to pay a trading cost depending on the equilibrium bid ask spread and their volume (i.e., $EC_{M+N} = \lambda \text{ var}(\Sigma\theta_n + \Sigma\Delta_m \mid y^*=y^*)$). The D + 1 uninformed liquidity traders have no expected revenue from trading because their trading strategies are not correlated with the future value of the security. Nonetheless, they have to pay a trading cost which as usual depends on the equilibrium bid ask spread and their volume of trade (that is, $EC_{D+1} = \lambda \text{ cov}(u, z \mid y^*=y^*)$).

The securities market is a zero-sum game because the sum of the payoffs of all the participants is zero whatever strategies they choose (see, e.g., Fudenberg and Tirole (1991), page 4). It may seem strange to pay attention to the expected welfare in a zero-sum game because the expected trading profits are just transfers between traders which give no social surplus. However, there is, as shown in table 4.2, expected to be productive effort, but it is not affected by security trading.

<u>TABLE 4.2</u>:	Expected profit
Net profit from trading in security k at time t	0
+ Expected production in firm k from time t to t + 1	$E[\tilde{\delta} \mid \tilde{y}^* = y^*]$
= Social surplus	$E[\tilde{\delta} \mid \tilde{y}^* = y^*]$

This social surplus is received by current shareholders who are assumed to follow a buy-and-hold strategy (i.e., they do not trade at all in the period). In chapters 5 - 6, I extend to a corresponding production and exchange economy where the corporate insiders may affect the social surplus and thereby the welfare of the current shareholders. Until then $E[\delta \mid y^*=y^*]$ is given exogenously, and is not taken into consideration. This limits the analysis to the welfare of future shareholders holding either long or short positions in security k from time t to time t+1.

4.2.1 Expected profit to market makers

I have assumed that there are a limited number of market makers. Nonetheless, they act competitively when they determine how sensitive the transaction price should be to changes in the net order flow. This implies that competition forces market maker $q \in \{1, 2, ..., Q\}$ to set the price sensitivity to make zero expected profit (see (2.2.15)).

$$\text{(2.1)} \qquad E\left[\tilde{z}_q (R\tilde{S} - \tilde{x}) \mid \tilde{y}^* = y^*\right] \equiv 0,$$

where $z_q = z / Q$ is the position of the market maker. This is the equilibrium condition in the dealership market, and it gives the equilibrium price, the price sensitivity, and the equilibrium bid ask spread (see (2.3.7), (2.3.8), and (3.3.2)).

In chapter 5, I extend to a production and exchange economy where the market makers expect to earn a positive profit (to compensate for the cost of enforcing the law prohibiting insider trading; see lemma 5.4), and, in chapter 8, to an exchange economy where the risk averse market makers have market power and may therefore set the equilibrium bid ask spread above the spread determined by (2.1); see lemma 8.1. In this way, they expect to earn a positive risk adjusted profit.

4.2.2 Expected profit to informed speculators

The superiorly informed speculators expect to earn a positive revenue on privately acquired information. This is as mentioned because their trading strategies are correlated with the end-of-period value of the risky asset. They have, nonetheless, to pay a trading cost which depends on the equilibrium bid ask spread and their trading volume.

Lemma 4.1: *Suppose $L = A$ and the stock market equilibrium $[(\theta_{nkt}, \Delta_{mkt}, u_{dkt}), S_{kt}; k \in \{1, 2, ..., K\}, t \in \{0, 1, ..., T_k\text{-}1\}]$ is given by lemma 2.1, then corporate insider $m \in \{1, 2, ..., M\}$ and market professional n*

$\in \{1, 2, ..., N\}$ expect to earn

$$(2.2) \qquad E\left[\tilde{\pi}_m^M \mid \tilde{y}^* = y^*\right] = \frac{\alpha^2 (\Gamma + \eta)\Gamma}{N\Gamma + (M+1)(\Gamma+\eta)\alpha}\sqrt{\frac{\sigma}{N(\Gamma+\varepsilon) + M(\Gamma+\eta)\alpha^2}}, \text{ and}$$

$$(2.3) \qquad E\left[\tilde{\pi}_n^N \mid \tilde{y}^* = y^*\right] = \frac{(\Gamma + \varepsilon)\Gamma}{N\Gamma + (M+1)(\Gamma+\eta)\alpha}\sqrt{\frac{\sigma}{N(\Gamma+\varepsilon) + M(\Gamma+\eta)\alpha^2}}.$$

If $L = B$, then μ replaces M.

Proof: See appendix A.

Of course, privately informed speculators have incentives to take short or long positions in the risky assets if they expect on the basis of privately acquired information to make a larger profit than investing in the riskless asset (which gives zero profit). Thus,

$$(2.4) \qquad E[\tilde{\pi} \mid \tilde{y}^* = y^*] > 0, \text{ or } E[\tilde{r} \mid \tilde{y}^* = y^*] > r \geq 0.$$

where r is the return from investing in security k from time t to time t+1 and r is the riskless rate of return. In chapter 7, I extend to a corresponding stock market where the informed speculators are risk averse; see lemmas 7.5 - 7.6 for the risk adjusted values of inside and privately acquired information.

Expected profit when $N = 0$

Figure 4.1 below indicates that the expected profit of market professionals decreases for small supply of corporate insiders (that is when $\mu < \mu_n$ where μ_n is a constant). This suggests that, for an appropriate number of corporate insiders, the professionals may be squeezed out of the market by better informed traders since they are not able to cover their informational investments. Corollary 4.1 gives the equilibrium in a market where N = 0.

Corollary 4.1: Suppose the market professionals are in zero supply, then

(2.5) $$\lim_{N \to 0} E\left[\tilde{\pi}_n^N(N) \mid \tilde{y}^* = y^*\right] = \frac{(\Gamma + \varepsilon)\,\Gamma}{(M + 1)(\Gamma + \eta)\,\alpha^2} \sqrt{\frac{\sigma}{M(\Gamma + \eta)}}, \textit{ and}$$

(2.6) $$E\left[\tilde{\pi}_m^M \mid \tilde{y}^* = y^*\right] = \frac{\Gamma}{M + 1} \sqrt{\frac{\sigma}{M(\Gamma + \eta)}}.$$

If $L = \mathbf{B}$, then μ replaces M.

Proof: Set N = 0 in lemma 4.1. Q.E.D.

If the smart money investors for some reason are in zero supply, they do not make any trading profits because N $E[\pi^N_n(N) \mid y^*=y^*] = 0$. The trading profits of corporate insiders are expected to increase due to less competition from the market professionals. This is confirmed by (2.2) because $E[\pi^M_m(N \to 0) \mid y^*=y^*] > E[\pi^M_m(N > 0) \mid y^*=y^*]$.

Expected profit when μ or M = 0

Now assume that L changes from A to **B**, then the stock market equilibrium is given by corollary 2.2. The special case where $\mu = 0$ (or $M = 0$) is given by corollary 2.3. What are the effects on the expected profits earned by the informed traders?

Corollary 4.2: Suppose insider trading is effectively forbidden, then

(2.7) $$E\left[\tilde{\pi}_n^N \mid \tilde{y}^* = y^*\right] = \frac{\Gamma}{(N + 1)\Gamma + 2\varepsilon} \sqrt{\frac{(\Gamma + \varepsilon)\,\sigma}{N}}, \textit{ and}$$

$$(2.8) \qquad \lim_{\mu \to 0} E\left[\tilde{\pi}_m^M(\mu) \mid \tilde{y}^* = y^*\right] = \frac{(\Gamma + 2\,\varepsilon)^2\,\Gamma}{(\Gamma + \eta)\left[(N + 1)\,\Gamma + 2\,\varepsilon\right]} \sqrt{\frac{\sigma}{N\,(\Gamma + \varepsilon)}}.$$

Proof: Set $\mu = 0$ in lemma 4.1. Q.E.D.

Corporate insiders who follow L = B expect no trading profits because $\mu\, E[\pi^M{}_m(\mu) \mid y^*=y^*] = 0$. Naturally, the market professionals expect to earn a positive profit by exploiting the uninformed noise or liquidity traders alone. In fact, $E[\pi^N{}_n(\mu \to 0) \mid y^*=y^*] > E[\pi^N{}_n(\mu > 0) \mid y^*=y^*]$.

Common vs. diverse information

I compare the value of a signal shared by several individuals with the value of a corresponding signal observed by one individual alone given that the signals are of the same quality but not perfectly correlated.

Corollary 4.3: Diverse information represented by the signal y_n is worth more than corresponding common information represented by the signal y.

Proof: If $\varepsilon = \eta$ and N = M, then (2.6) is less than (2.7). Q.E.D.

This result is intuitive as observing a personal signal must be worth more than observing an otherwise identical signal which is shared by several others because of less competition. Nevertheless, I have assumed that the precision of the signals observed by the market professionals are noisier than the signal shared by the corporate insiders (see (2.2.10)). This means that y may be worth more than y_n.

4.2.3 Cost of liquidity trading

According to table 4.1, the liquidity traders have to pay a premium for the "privilege" to place or withdraw their liquidity surplus in the stock market. The premium equals the price sensitivity multiplied with their trading volume.

Lemma 4.2: *Suppose $L = A$ and the stock market equilibrium $[(\theta_{nkt}, \Delta_{mkt}, u_{dkt}), S_{kt}; k \in \{1, 2, ..., K\}, t \in \{0, 1, ..., T_k-1\}]$ is given by lemma 2.1, then the expected profit of liquidity traders is*

$$(2.9) \quad E\left[\sum_{d=0}^{D} \tilde{\pi}_d^D \mid \tilde{y}^* = y^*\right] = -\frac{\Gamma}{N\Gamma + (M + 1)(\Gamma + \eta)\alpha}\sqrt{\left[N(\Gamma + \varepsilon) + M(\Gamma + \eta)\alpha^2\right]}\,\sigma.$$

If $L = B$, then μ replaces M.

Proof: See appendix B.

We observe that the trading cost of liquidity traders is minimized if $\sigma = 0$. But uninformed traders who usually follow a buy-and-hold strategy must trade as noise traders when liquidity events occur exogenously. This does not imply that the liquidity traders are irrational, but it is easy to viewed them as irrational because

$$(2.10) \quad E\left[\sum_{d=0}^{D} \tilde{\pi}_d^D \mid \tilde{y}^* = y^*\right] < 0.$$

They are better off placing their surplus liquidity in cash because $r \geq 0$. On the other hand, the liquidity traders may have gains from trading which are not specified in this model, for example, the excitement of trading or the liquidity traders might be endowed with stocks so that at least their net profit is positive. In this way, the noise or liquidity traders are referred to as semi-rational. In chapter 7, I extend to the securities market where the liquidity traders are risk averse; see lemma 7.4 for the risk adjusted value of random liquidity trading.

Trading cost when N = 0

If there are no market professionals, the trading cost of noise traders occurs because of the adverse selection problem caused by corporate insiders.

Corollary 4.4: Suppose the market professionals are completely crowded out of the securities market by other informed traders, then

(2.11)
$$E\left[\sum_{d=0}^{D} \tilde{\pi}_d^D \mid \tilde{y}^* = y^*\right] = -\frac{\Gamma}{M+1}\sqrt{\frac{M\sigma}{\Gamma+\eta}}.$$

If $L = B$, then μ replaces M.

Proof: Set N = 0 in (2.9). Q.E.D.

If no smart money investors are entering the stock market, the liquidity traders are only exploited by the corporate insiders.

Trading cost when μ or M = 0

If there are no corporate insiders, the trading cost of liquidity traders depends only on the adverse selection problem caused by the market professionals.

Corollary 4.5: Suppose insider trading is forbidden and effectively enforced by the stock market regulators, then

(2.12)
$$E\left[\sum_{d=0}^{D} \tilde{\pi}_d^D \mid \tilde{y}^* = y^*\right] = -\frac{\Gamma}{(N+1)\Gamma + 2\varepsilon}\sqrt{N(\Gamma+\varepsilon)\sigma}.$$

Proof: Set μ = 0 in (2.9). Q.E.D.

In this case, the liquidity traders have only to pay a premium to the market professionals through the adverse selection component in the equilibrium bid ask spread.

4.3 EFFECTS ON THE WELFARE OF INFORMED SPECULATORS

Before I analyze how the expected profit of superiorly informed traders depends on the supply of corporate insiders, I compare the expected profit of the corporate insiders with the expected profit of the market professionals.

3.1 Comparisons of the two types of informed speculators

Is it really true that corporate insiders earn a higher expected profit than other informed speculators trading on private information? This section gives some answers.

Proposition 4.1: *The expected profits of informed speculators are related in the following way*

$$E\left[\tilde{\pi}_m^M \mid \tilde{y}^* = y^*\right] = \alpha\, E\left[\tilde{\pi}_n^N \mid \tilde{y}^* = y^*\right], \tag{3.1}$$

where

$$\alpha = \frac{d\,E\left[\pi_m^M \mid \tilde{y}^* = y^*\right]}{d\,E\left[\pi_n^N \mid \tilde{y}^* = y^*\right]} = \frac{\Gamma + \eta}{\Gamma + \varepsilon}\,\alpha^2 > 0. \tag{3.2}$$

Proof: This follows directly from (2.2) and (2.3). Q.E.D.

If there is one insider as in Fishman and Hagerty (1992), the insider expects to earn more than any of the professionals. This is because private information is by assumption noisier than inside information (see (2.2.10)). If there are several insiders and provided that the quality of the information is not too different, a professional might expect to earn more than a insider. For instance, if ε increases, the corporate insiders expects to earn more relative to the market professionals because d α / d $\varepsilon > 0$.

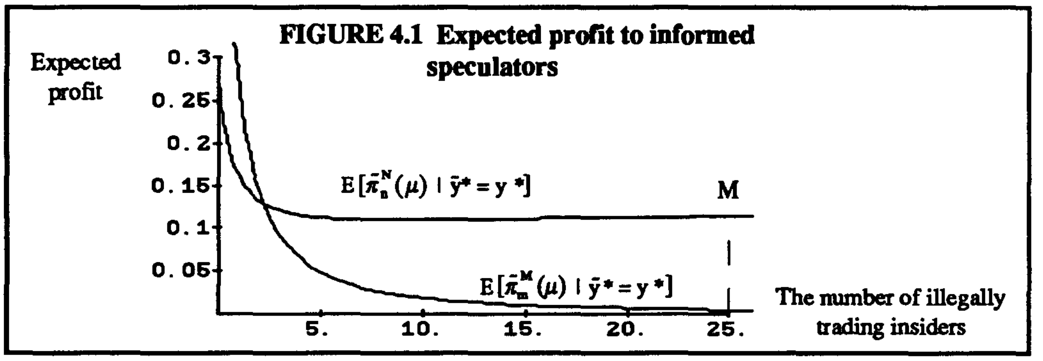
Proposition 4.2: Suppose

(3.3) $$\mu < \mu^{*} = \frac{\Gamma + 2\varepsilon}{\eta}\sqrt{\frac{\Gamma + \eta}{\Gamma + \varepsilon}} - \frac{\Gamma + \eta}{\eta},$$

then insider $m \in \{1, 2, ..., \mu\}$ expects to earn more than professional $n \in \{1, 2, ..., N\}$. Otherwise professional n expects to earn at least as much as insider m. If $\eta = 0$, a corporate insider always expects to earn more than any of the market professional.

<u>Proof</u>: According to (3.1), $\alpha > 1$ if $E[\pi^{\mu}_{m} \mid y^{*}=y^{*}] > E[\pi^{N}_{n} \mid y^{*}=y^{*}]$. I solve the inequality $\alpha = 1$ with respect to μ and $\mu^{\bullet}$ follows, suggesting that $\alpha > 1$ if $\mu < \mu^{\bullet}$. We see directly that if $\eta = 0$, $E[\pi^{\mu}_{m} \mid y^{*}=y^{*}] > E[\pi^{N}_{n} \mid y^{*}=y^{*}]$ for all $\mu < \infty$ because $\mu < \mu^{\bullet} \rightarrow \infty$. Finally, notice that if $\mu \rightarrow \infty$ and $\eta = 0$, then $E[\pi^{\mu}_{m} \mid y^{*}=y^{*}] = E[\pi^{N}_{n} \mid y^{*}=y^{*}] = 0$ because the equilibrium is fully revealing. Q.E.D.

Figure 4.1 illustrates the expected profit of the corporate insiders and the market professionals as functions of the number of corporate insiders breaking the law. I have used the numerical values given in table 3.3; see appendix 3.D.



In this example, I have increased M from 10 to 25. We observe that if $\mu < \mu^{\bullet} = 2.196$, then each corporate insider might expect a higher trading profit than each of the outside professionals. Otherwise, a market professional expects to earn more.

3.2 Comparisons across equilibria

I compare the expected profit when insider trading is allowed with the expected profit when insider trading is prohibited.

Corporate insiders

The expected profit to corporate insiders depends on their supply, and, of course, whether a particular insider is able to trade or not.

Proposition 4.3: *If the supply of corporate insiders changes exogenously, the effect on their expected profit is*

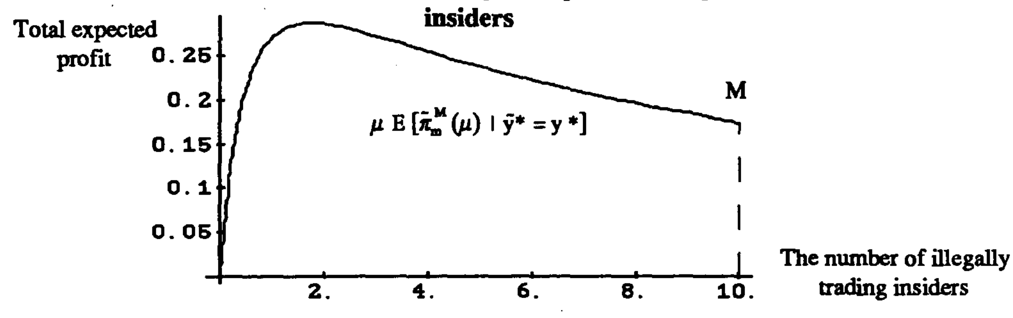
$$(3.4) \qquad \frac{d\,E\left[\tilde{\pi}_m^{\mu} \mid \tilde{y}^* = y^*\right]}{d\,\mu} < 0.$$

The limit is $E[\pi^{\mu}_m(\mu \to \infty) \,/\, y^*=y^*] = 0$. *Finally,* $\lim_{\mu \to 0} \mu\, E[\pi^{\mu}_m(\mu) \,/\, y^*=y^*] = 0$.

Proof: I use (2.2) and differentiate with respect to the number of illegally trading insiders. The limits follow from (2.2) without any difficulties. Q.E.D.

In other words, if the supply of corporate insiders increases exogenously, the expected profit of corporate insiders, who are able to trade illegally because of camouflage provided by other traders, decreases due to higher competition in exploiting their common signal y. This is confirmed in figure 4.1. But what is happening to the total expected profit? Figure 4.2 illustrates.

FIGURE 4.2 Total expected profit to corporate insiders



We observe that if $\mu > 1.761$, the total expected profit decreases. This is because when there are several corporate insiders, there is competition which dominates the effect caused by a greater number of insiders and the total expected profit falls. At the limit when $\mu \to \infty$, then the total expected profit converges toward zero because the insiders' common information signal y is completely transmitted into the equilibrium order flow and thereby into the transaction price.

Corollary 4.6: *Suppose L changes from A to **B**, then*

(3.5) $$E\left[\tilde{\pi}_m^{\mu}(\mu) \mid \tilde{y}^* = y^*\right] \geq E\left[\tilde{\pi}_m^{M}(M) \mid \tilde{y}^* = y^*\right].$$

Proof: This follows from (3.4) since $\mu \leq M$. Q.E.D.

If some of the corporate insiders trade illegally, they meet reduced competition and therefore expect to earn a higher profit. This means that a corporate insider may favor L = **B** if he expects to trade illegally without being discovered which might be possible because of the camouflage provided by the outsiders.

Market professionals

I am now turning to the welfare of the outsiders who are choosing to acquire private information at a cost $C \geq 0$. It is, however, sufficient to analyze the gross trading profit since C is assumed to be independent of the supply of corporate insiders.

Proposition 4.4: *If the supply of corporate insiders changes, the direction of the effect on the expected profit of market professionals is determined by*

$$(3.6)\ \mathrm{Sgn}\left(\frac{d\,E\left[\tilde{\pi}_n^N \mid \tilde{y}^*=y^*\right]}{d\mu}\right) = -\ \mathrm{Sgn}\left(\frac{\Gamma}{N\Gamma + (\mu+1)(\Gamma+\eta)\alpha} + \frac{\alpha(\Gamma + (1-\mu)\eta)}{N(\Gamma+\varepsilon) + \mu(\Gamma+\eta)\alpha^2}\right).$$

If $\eta = 0$, then $d\,E[\pi^N_n \,/\, y^*=y^*] \,/\, d\,\mu < 0$ for all μ. On the other hand, if $\eta > 0$, $E[\pi^N_n(\mu = 0) \,/\, y^*=y^*] \,/\, d\,\mu <$ 0 and $E[\pi^N_n(\mu > \mu_n) \,/\, y^*=y^*] \,/\, d\,\mu > 0$ where μ_n is determined by $E[\pi^N_n(\mu_n) \,/\, y^*=y^*] \,/\, d\,\mu = 0$. Finally, notice the relation $E[\pi^N_n(\mu = 0) \,/\, y^*=y^*] > E[\pi^N_n(\mu \to \infty) \,/\, y^*=y^*] \geq 0$ where the limit $E[\pi^N_n(\mu \to \infty) \,/\, y^*=y^*]$ $= 0$ if $\eta = 0$.

Proof: I differentiate (2.3) with respect to μ, and obtain straightforwardly the sign determined by (3.6). If $\eta =$ 0, the sign is negative, and if $\eta > 0$, the derivative must change sign. The expected profit when $\mu = 0$ is given by (2.7), and the limit when the number of insiders grows to infinity is

$$(3.7)\qquad E\left[\tilde{\pi}_n^N(\mu \to \infty) \mid \tilde{y}^*=y^*\right] = \frac{\Gamma}{N\Gamma + \dfrac{(\Gamma+2\varepsilon)(\Gamma+\eta)}{\eta}}\sqrt{\frac{(\Gamma+\varepsilon)\sigma}{N}}.$$

We observe that (3.7) is less than (2.7). If $\eta > 0$, $E[\pi^N_n(\mu \to \infty) \mid y^*=y^*] > 0$ and if $\eta = 0$, $E[\pi^N_n(\mu \to \infty) \mid$ $y^*=y^*] = 0$. Q.E.D.

Figure 4.1 shows that if $\mu < \mu_n = 9.291$ where μ_n is determined by $d\,E[\pi^N_n(\mu_n) \mid y^*=y^*] \,/\, d\,\mu = 0$, $E[\pi^N_n(\mu) \mid$ $y^*=y^*]$ decreases from 0.283 when $\mu = 0$ to 0.110 when $\mu = \mu_n$. Otherwise, the expected profit increases and converges toward 0.129 as μ converges toward infinity.

Roughly speaking, if the supply of corporate insiders changes as a result of tightened insider trading regulations, it is a trade-off between two effects which determine the change in the expected profit of legally trading market professionals:

- If the supply of corporate insiders decreases, the market professionals face less competition in exploiting superior information which in turn increases their expected profit.
- If the supply of corporate insiders decreases, the market makers face a change in their adverse selection or price differentiation problem. (i) If the supply decreases from M to $\mu > \mu_\lambda$, the price differentiation problem increases, leading to a higher bid ask spread and thereby to a higher trading cost for all traders because the market power of the remaining corporate insiders increases. (ii) However, if the supply decreases from M to $\mu < \mu_\lambda$, the price differentiation problem may be reduced due to no or a very moderate "presence-of-insider" effect. This reduction of this effect decreases the spread and thereby the trading cost. Thus, this adverse selection effect might be positive or negative for the market professionals, depending on from and to where the supply of corporate insiders changes.

This means that the total effect depends on the direct competition and the adverse selection. Table 4.3 summarizes the effects.

TABLE 4.3: Welfare effects caused by $\Delta\mu$

$\Delta\mu$	Ce	As	Total
$\mu \in [0, \mu_\lambda]$	-	-	-
$\mu \in (\mu_\lambda, \mu_n]$	-	+	-
$\mu \in (\mu_n, \infty)$	-	+	+

Ce = Competition effect, As = Adverse selection, and μ_λ, μ_n are constants ($\mu_\lambda < \mu_n$)

According to the example, if $\mu \in [0, \mu_\lambda = 0.512)$, the direct competition and the adverse selection effect are negative where μ_λ is the maximum illustrated in figure 3.3. If $\mu \in [\mu_\lambda = 0.512, \mu_n = 9.291)$, the direct competition effect is negative and the adverse selection effect is positive. The expected profit to market professionals falls since the direct competition effect dominates the adverse selection effect. Nevertheless, when $\mu \geq \mu_n = 9.291$, the positive adverse selection effect dominates the negative direct competition effect. This means that the expected profit of market professionals increases.

Corollary 4.7: *Suppose L changes from A to B when $M < M_n$ (where M_n is the solution to the equation $d E[\pi^N{}_n(M_n) / y^*=y^*] / d M = 0$), then*

$$(3.8) \qquad E\left[\tilde{\pi}_n^N(\mu) \mid \tilde{y}^* = y^*\right] \geq E\left[\tilde{\pi}_n^N(M) \mid \tilde{y}^* = y^*\right].$$

If $\eta < 0$, the opposite might happen if the firm is large (that is when $M > M_n$) and the regulators' enforcement is not very effective.

Proof: If $M < M_n$, (3.8) follows from (3.6) since $\mu \leq M$. Q.E.D.

Market professionals prefer insider trading prohibited on every exchange where corporate insiders observe perfect information. However, it may not be the case on other exchanges where the corporate insiders are "allowed" to trade illegally on noisy information.

4.4 EFFECTS ON THE WELFARE OF UNINFORMED LIQUIDITY TRADERS

According to table 4.1, the expected trading cost of liquidity traders equals the price sensitivity multiplied with their expected trading volume.

Proposition 4.5: *Suppose the supply of corporate insiders changes exogenously, then the direction of the effect on the expected profit of liquidity traders is determined by*

$$(4.1) \quad \mathrm{Sgn}\left(\frac{d E\left[\sum_{d=0}^{D} \tilde{\pi}_d^D \mid \tilde{y}^* = y^*\right]}{d\mu}\right) = \mathrm{Sgn}\left(\frac{2\Gamma}{N\Gamma + (\mu + 1)(\Gamma + \eta)\alpha} - \frac{\alpha(\Gamma + (1 - \mu)\eta)}{N(\Gamma + \varepsilon) + \mu(\Gamma + \eta)\alpha^2}\right).$$

If $\mu \geq \mu_\lambda$ (where $d E[\Sigma\pi^D{}_d(\mu_\lambda) / y^*=y^*] / d\mu = 0$), then $d E[\Sigma\pi^D{}_d(\mu) / y^*=y^*] / d\mu > 0$. If $\eta > 0$, $E[\Sigma\pi^D{}_d(\mu = 0) / y^*=y^*] < E[\Sigma\pi^D{}_d(\mu \to \infty) / y^*=y^*] < 0$. However, if $\eta = 0$, $E[\Sigma\pi^D{}_d(\mu \to \infty) / y^*=y^*] = 0$.

Proof: I differentiate (2.9) with respect to μ, and obtain (4.1) straightforwardly. We observe directly that the sign is positive for $\mu > \mu_\lambda$ and negative for $\mu < \mu_\lambda$. If $\eta = 0$, then μ_λ is easy to find, but if $\eta > 0$, the solution is complex, but easy to find numerically. If $\mu = 0$, the expected profit is given by (2.12). I use (2.9) to show that

$$(4.2) \qquad E\left[\sum_{d=0}^{D} \tilde{\pi}_d^D(\mu \to \infty) \mid \tilde{y}^* = y^*\right] = -\frac{\Gamma}{N\Gamma + \dfrac{(\Gamma + 2\varepsilon)(\Gamma + \eta)}{\eta}} \sqrt{N(\Gamma + \varepsilon)}\,\sigma.$$

This limit is negative and larger than $E[\Sigma\pi^D{}_d(\mu = 0) \mid y^*=y^*]$. We observe when $\eta = 0$ that $E[\Sigma\pi^D{}_d(\mu \to \infty) \mid y^*=y^*] = 0$. Q.E.D.

The trading cost of liquidity traders depends on the price differentiation problem faced by the price setting market makers. There are two effects:

(i) If the number of illegally trading insiders increases from $\mu = 0$ to $\mu < \mu_\lambda$, there is what we might call a "presence-of-insider" effect. It increases the adverse selection component in the bid ask spread, and thereby increases the trading cost of traders who are trading, for instance, to raise cash by selling out shares from their inventory.

(ii) If the number of illegally insiders increases further (that is beyond μ_λ), there is a "lack-of-coordination" effect which reduces the market power of the corporate insiders. This lessens the adverse selection component in the equilibrium bid ask spread which is advantageous for uninformed traders because it reduces their trading cost.

Strictly speaking, the two effects are the same effect which we might call the adverse selection effect. This effect is negative if the supply shifts from zero to approximately one, and positive if the supply of corporate insiders shifts from one to several.

Corollary 4.8: *Suppose L changes from A to B and $M > M^\bullet$ (where $M^\bullet > 0$ is determined by $E[\Sigma\pi^D{}_d(M^\bullet) \mid y^*=y^*] = E[\Sigma\pi^D{}_d(\mu = 0) \mid y^*=y^*]$), then*

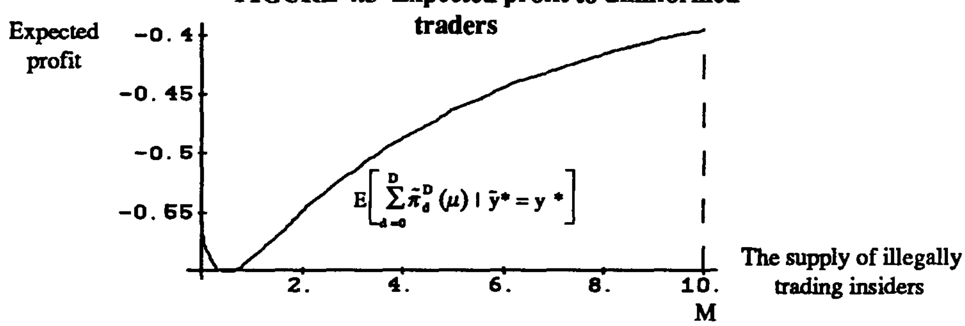
$$(4.3) \qquad E\left[\sum_{d=0}^{D}\tilde{\pi}_d^D(\mu) \mid \tilde{y}^* = y^*\right] \le E\left[\sum_{d=0}^{D}\tilde{\pi}_d^D(M) \mid \tilde{y}^* = y^*\right].$$

If $M \le M^\bullet$, the opposite happens.

Proof: This follows from (4.1) since $\mu \le M$. Q.E.D.

Figure 4.3 illustrates the expected profit of following a trading strategy u_d of buying and selling shares randomly.

FIGURE 4.3 Expected profit to uninformed traders



We observe that the expected profit is U-formed, and the trading cost is maximized if $\mu_\lambda = 0.512$, giving a total cost 0.601. If the supply changes from one to zero, the trading cost falls from 0.601 to 0.566, or to 0.395 if insider trading is allowed. This indicates that uninformed traders prefer insider trading outlawed in small companies where $M < M^\bullet = 1.641$. But if $M > M^\bullet$, the liquidity traders prefer insider trading allowed because of the additional competition.

4.5 TRADING COST WHEN THE SUPPLY OF MARKET PROFESSIONALS IS ELASTIC

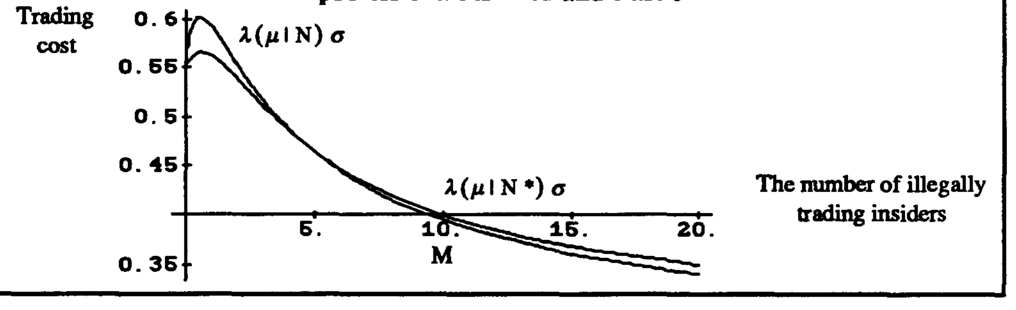
I have so far assumed that the supply of market professionals is fixed which means that $N^* = N$ for all μ. In this section, however, I assume that the supply is determined by the equilibrium condition in the market for acquiring private information:

$$\text{(5.1)} \qquad E\left[\tilde{\pi}_n^N(\mu) \mid \tilde{y}^* = y^*\right] - C = 0, \text{ for all } \mu \in \{1, 2, \ldots, M\},$$

where $C \geq 0$ is the cost of market professional $n \in \{1, 2, \ldots, N^*\}$ when acquiring the signal y_n. The equilibrium supply of market professionals is determined by solving this zero expected profit condition with respect to N. This means that $N^* = N^*(\mu, \ldots)$, and, according to (3.6.3), the supply of corporate insiders typically reduces the supply of market professionals because of the increased competition in exploiting superior information.

There are no effects caused by insider trading on the welfare of market professionals since they earn zero expected profit for all supply of corporate insiders, but the expected trading cost of liquidity traders is affected by this change in market structure. Figure 4.4 illustrates the expected trading cost using the numerical values given in table 3.3.

FIGURE 4.4 Trading cost when the supply of market professionals is fixed and elastic



If $N^* = N$, $\lambda(\mu^{\bullet\bullet} \mid N) = \lambda(\mu^{\bullet\bullet} \mid N^*)$ which corresponds to a specific supply of corporate insiders $\mu^{\bullet\bullet}$ (approximately 5 in the example).

Proposition 4.6: *If $N, N^* > N_\lambda$ (where N_λ is determined by $d\,\lambda(N_\lambda) / dN = 0$), then*

$$\text{(5.2)} \qquad \begin{cases} 0 < \mu < \mu^{\bullet\bullet} \Rightarrow & \lambda(\mu \mid N) > \lambda(\mu \mid N^*) \text{ since } N^* > N, \\ \mu \geq \mu^{\bullet\bullet} \Rightarrow & \lambda(\mu \mid N) \leq \lambda(\mu \mid N^*) \text{ since } N^* \leq N. \end{cases}$$

Proof: If, as I have assumed, $\lambda(N)$ is decreasing in N (and N*), these relations follow directly from the definition of $\mu^{\bullet\bullet}$. Obviously, the condition $N > N_\lambda$ secures that $d\,\lambda(N) / d\,N < 0$. This is because, according to (2.3.8),

$$\text{(5.3)} \qquad \mathrm{Sgn}\left(\frac{d\,\lambda}{d\,N}\right) = -\,\mathrm{Sgn}\Big(N\,(\Gamma + \varepsilon)\,\Gamma + \alpha\big[2\,\alpha\,\Gamma - (\mu + 1)\,(\Gamma + \varepsilon)\big]\,(\Gamma + \eta)\Big).$$

Q.E.D.

We observe that for small numbers of corporate insiders, the equilibrium bid ask spread decreases if the competition in the securities industry changes from oligopolistic competition with a fixed supply to "perfect" competition with an elastic supply of market professionals.

Proposition 4.7: *Suppose there are entry barriers into the securities industry (and no exit barriers out of the industry), then*

$$\text{(5.4)} \qquad E\left[\sum_{d=0}^{D} \tilde{\pi}_d^D(\mu) \mid \tilde{y}^* = y^*, N^*\right] \geq E\left[\sum_{d=0}^{D} \tilde{\pi}_d^D(\mu) \mid \tilde{y}^* = y^*, N\right].$$

Proof: If N is fixed and $C > 0$, the trading cost of uninformed traders is

$$\text{(5.5)} \qquad \begin{cases} \lambda(\mu \mid N)\,\sigma, & \text{if } \mu \leq \mu^{\bullet\bullet}, \text{ and} \\ \lambda(\mu \mid N^*)\,\sigma, & \text{if } \mu > \mu^{\bullet\bullet}. \end{cases}$$

The first follows directly, and the second follows because if the trading cost was $\lambda(\mu \mid N)\,\sigma$ when $\mu > \mu^{\bullet\bullet}$, the market professionals loose money and would leave. This means that the market is elastic for supplies greater than $\mu^{\bullet\bullet}$, but not necessarily for supplies less than $\mu^{\bullet\bullet}$, e.g., because of entry barriers. According to (5.2), $\lambda(\mu \mid N) \geq \lambda(\mu \mid N^*]$ which implies that (5.4) holds. Q.E.D.

The liquidity traders are better off when there is an elastic supply than when there is a fixed supply of market professionals. This is because it is better to trade together with market professionals who are trading away all tendencies of economic rents in the securities industry than together with professionals who expect to make a profit.

*Corollary 4.9: Suppose L is changed from **A** to **B**, then the uninformed liquidity traders simultaneously prefer increased competition among the market professionals.*

Proof: According to (5.4), the liquidity traders are always better off when there is free entry of market professionals. Q.E.D.

This suggests that if L is to be changed from **A** to **B**, then, according to (4.3), this might have negative consequences for the liquidity traders. These are reduced if the stock market regulators simultaneously increases the competition in the securities industry. One way of doing this is to remove potential entry barriers in the legislation.

4.6 DISCRETIONARY LIQUIDITY TRADERS

I draw on Admati and Pfleiderer (1988) who divide the noise or liquidity traders into discretionary and non-discretionary liquidity traders. The difference is that the discretionary liquidity traders are semi-rational because they may decide where and when to execute their liquidity need. This section analyzes where and when the discretionary liquidity traders should trade to minimize their expected trading cost when insider trading may be prohibited or allowed.

According to (2.2.14), the discretionary liquidity traders increase the total liquidity trading in security $k \in \{1, 2, ..., K\}$ at time $t \in \{0, 1, ..., T_k - 1\}$ if they are concentrating their trading in this particular security and period. The demand from discretionary liquidity trader $d \in \{1, 2, ..., D\}$ is determined outside the model, but it is optimal to trade u_d in the security and at the time where it is expected to be cheapest to trade within the liquidity trader's window of discretion.

Proposition 4.8: *It is optimal for discretionary liquidity traders to trade in the period and the security with the lowest expected bid ask spread inside their windows of discretion $[t, t + \tau]$ and $[k, k + \kappa]$. There exists an equilibrium in which the discretionary liquidity traders are concentrating their trades, and if there is a certain amount of informed trading, the equilibrium also implies concentrating with as many informed traders as possible.*

Proof: Obviously, if $\lambda_{k,t} < \lambda_{k+1,t+1}$ and discretionary liquidity trader d is able to choose between trading security k at auction t and security k+1 at action t + 1, it is optimal to trade in security k at auction t. This is because the expected trading cost of trader d is $\lambda\ \sigma_d$, and, according to (2.3.8), it is optimal to trade with as many other liquidity traders as possible since $d\lambda / d\sigma < 0$. Among the discretionary liquidity traders, this leads to as concentrated trading as possible. Suppose there exists a security and a period where $N = 0$ and $\mu = 0$, then $\lambda = 0$, leading to concentration of discretionary liquidity traders with this period and security in their windows of discretion. On the other hand, suppose $N > N_\lambda$ and $\mu > \mu_\lambda$, then it is optimal to trade with as many informed traders as possible. This is because when these inequalities are satisfied, λ is, per definition, falling with N and μ. Q.E.D.

This proposition is analogous to proposition 1 in Admati and Pfleiderer (1988), proposition 4 in Pagano (1989), and proposition 1 in Subrahmanyam (1991). Admati and Pfleiderer find that the discretionary liquidity traders have an incentive to bunch their trades in a single period (temporal concentration), whereas Pagano and Subrahmanyam find that the discretionary liquidity traders tend to trade in a single market and security (market and security concentration); see also Foster and Viswanathan (1990) and Chowdhry and Nanda (1991) for similar results.

If there is a stock index future, Subrahmanyam (1991) shows that it is optimal for the discretionary liquidity traders to concentrate their trading in the index. This is because firm specific or inside information is diversified away. Nevertheless, trading in the index may be viewed as diversified trading and not concentrated trading.

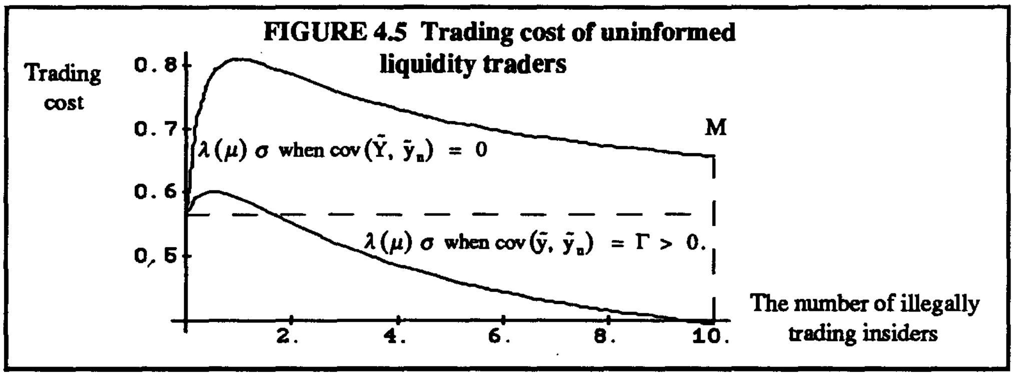
Correlated vs. uncorrelated information

I am now analyzing more closely the identified tendency of clustering, and focus especially on the clustering of trades in securities and periods where insiders are trading intensively (that is the second type of equilibria identified above). It turns out that this result depends critically on the assumption that inside information is correlated with the information acquired by the market professionals.

Proposition 4.9: *If the superiorly informed speculators observe uncorrelated information (i.e., $cov(Y, y_n) = 0$), the discretionary liquidity traders prefer to trade in a security and a period where there are no corporate insiders trading. If, on the other hand, the speculators observe correlated information (i.e., $cov(y, y_n) = \Gamma > 0$) and $N > N_\lambda$ and $\mu > \mu_\lambda$, the discretionary liquidity traders prefer to trade together with as many corporate insiders as possible.*

Proof: If the superiorly informed speculators observe uncorrelated information, the price sensitivity is given by (2.6.15), and it is minimized when $\mu = 0$. On the other hand, the price sensitivity is given by (2.3.8) if the superiorly informed speculators observe correlated information, and $\lambda(\mu)$ is minimized when μ is as large as possible. Q.E.D.

Figure 4.5 illustrates the trading cost as a function of the number of illegally trading insiders when $cov(Y, y_n) = 0$ and when $cov(y, y_n) = \Gamma > 0$. I use the numerical values given in table 3.3 (and assume that $\Phi = \Gamma$ and $\iota = \eta$; see section 2.6).



We observe that the trading cost in a securities market where the two types of superiorly informed speculators observe uncorrelated information is higher than in a corresponding market where they observe correlated information. Notice that when $\mathrm{cov}(Y, y_n) = 0$, then $\lambda(\mu = 0)\,\sigma = \lambda(\mu \to \infty)\,\sigma = 0.566 < \lambda(0 < \mu < \infty)\,\sigma$. This implies that the uniformed traders prefer insider trading prohibited and effectively enforced.

Proposition 4.11: *The liquidity traders prefer the two types of informed speculators to observe correlated rather than uncorrelated information.*

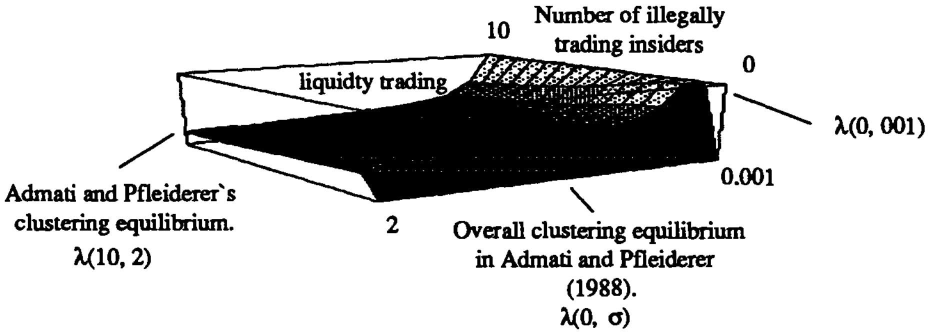
Proof: The price sensitivity is given by (2.3.8) when $\mathrm{cov}(y, y_n) = \Gamma > 0$ and by (2.6.15) when $\mathrm{cov}(Y, y_n) = 0$. If $\Gamma = \Phi$ and $\eta = \iota$, it follow directly by comparing (2.3.8) with (2.6.15) that the price sensitivity and thereby the bid ask spread are greater if the speculators observe uncorrelated signals than if they observe correlated signals. Q.E.D.

This suggests that one way of limiting the damage of insider trading on the welfare of liquidity traders is to increase the outsiders attention towards internal sources of information. This will make the information of market professionals correlated with inside information. Disclosure of firm specific information may make the two types of information more correlated.

More on my clustering equilibrium relative to the one in Admati and Pfleiderer (1988)

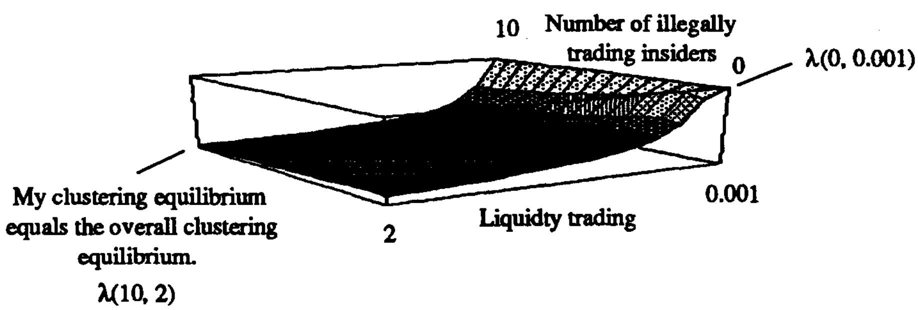
Figure 4.6 illustrates the price sensitivity as a function of both the number of illegally trading insiders and the amount of liquidity trading when where there are no market professionals as in lemma 1 on page 10 in Admati and Pfleiderer (1988).

FIGURE 4.6 Clustering without market professionals



As long as there is at least one illegally trading insider, the lowest cost equilibrium implies concentration of discretionary liquidity traders together with as many corporate insiders as possible. Nevertheless, if the liquidity traders could trade alone without any informed traders, the bid ask spread will be zero. This suggests that if the welfare of small uninformed traders is the primary concern of the stock market regulators, insider trading should be prohibited and the law should be effectively enforced. On the other hand, if there are both corporate insiders and market professionals, the lowest cost equilibrium is an equilibrium where the insiders trade illegally (or where insider trading is allowed by the regulators). Figure 4.7 illustrates the price sensitivity $\lambda(\mu, \sigma)$ when N = 2.

FIGURE 4.7 Clustering with market professionals



This example suggests that insider trading should be allowed if the welfare of small uninformed traders is the primary concern of stock market regulators. My clustering equilibrium equals the overall clustering equilibrium since it is not possible to prevent all informed trading (that is, prohibiting market professionals from trading). This is because private information may be established, e.g., because some of security analysts have superior skills when analyzing public information such the accounting report y*. Note, however, that figure 4.7 is very similar to figure 4.6. If the corporate insiders and the market professionals observe common information with the same precision ($\eta = \varepsilon$), the two figures are identical since the outside professionals are indistinguishable from the insiders.

4.7 ELASTIC SUPPLY OF LIQUIDITY TRADERS

The discretionary liquidity traders tend to cluster their trades when and where the corporate insiders are competing hard or when and where there are no insiders in the market at all. This suggests that the amount of liquidity trading may depend on the supply of corporate insiders. That is, $\sigma = \sigma(\mu)$. The analysis above indicates that $\sigma(\mu)$ should be U-shaped, large when μ is large and μ is zero. I assume instead that the amount of liquidity trading is falling with the supply of corporate insiders, and therefore concentrate on only one of the two types of clustering equilibria. This is consistent with the arguments saying that the outsiders loose "confidence" in markets with extensive trading by corporate insiders; see, e.g., Charlton and Fischel (1983), page 879 and Dennert (1991), page 196 for arguments along these lines. The amount of liquidity trading might therefore be a function

$$(7.1) \qquad \sigma(\mu) = \frac{\varsigma}{\mu + 1},$$

where $\varsigma > 0$ is the amount of liquidity trading when insider trading is prohibited and effectively enforced by the regulatory agency. This implies that $\sigma(\mu \to \infty) = 0$ as liquidity traders then have completely lost the "confidence" in the market, and the market has to close.

7.1 Welfare of liquidity traders

There are two types of liquidity traders. The first type is the traders who know that they are uninformed, but their liquidity events have not yet been realized. The second type is the traders whose liquidity events already have been realized.

Potential liquidity traders

The potential liquidity traders have a liquidity demand almost surely, but the size of their liquidity demand is still unknown. In this way, their expected welfare depends on the price sensitivity and their expected trading volume.

Proposition 4.12: *If σ is given by (7.1), then*

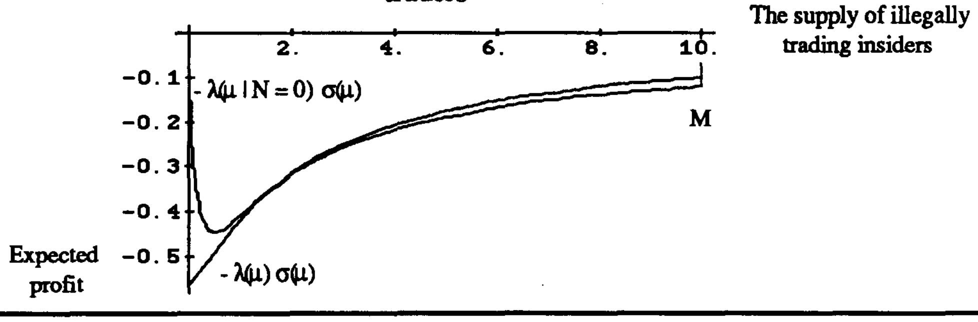
$$\text{(7.2)} \qquad \frac{\mathrm{d}\,\mathrm{E}\left[\sum_{d=0}^{D} \tilde{\pi}_d^{D}(\mu) \mid \tilde{y}^* = y^*\right]}{\mathrm{d}\,\mu} = -\left[\frac{\mathrm{d}\,\lambda(\mu)}{\mathrm{d}\,\mu}\,\sigma(\mu) + \lambda(\mu)\,\frac{\mathrm{d}\,\sigma(\mu)}{\mathrm{d}\,\mu}\right].$$

The sign may be positive for all μ, or negative for small μ and positive for larger $\mu \leq M$.

Proof: According to (B1), $\mathrm{E}[\sum \pi^D{}_d(\mu) \mid y^*=y^*] = -\lambda(\mu)\,\sigma(\mu)$, and (7.2) follows directly. Then I use (7.1), and find that $\mathrm{d}\,\sigma(\mu) / \mathrm{d}\,\mu < 0$. The next step is to substitute (7.1) into (2.3.8), and find that $\mathrm{d}\,\lambda(\mu) / \mathrm{d}\,\mu > 0$. This implies that the sign of $\mathrm{d}\,\mathrm{E}[\sum \pi^D{}_d(\mu) \mid y^*=y^*] / \mathrm{d}\,\mu$ may shift because there are two effects working in the opposite directions; see figure 4.8 for an example. Q.E.D.

The total effect caused by insider trading on the welfare of liquidity traders depends on the trade-off between the negative price effect and the positive volume effect. Figure 4.8 illustrates using the parametric values given table 3.3 and $\sigma(\mu = 0) = \varsigma = 1$.

FIGURE 4.8 Expected profit to uninformed traders



If $\mu = 0$, the trading cost is 0.566, and if $\mu \to \infty$, the trading cost approaches zero. In this example, the positive volume effect dominates for all μ. But if N = 0 and $\mu = 0$, the trading cost is 0, and then it decreases before it starts increasing towards zero. Thus, the negative price effect dominates the positive volume effect for small $\mu \leq M$.

Liquidity traders trading a known order size

If some of the liquidity traders know their demand with certainty, the effect caused by insider trading on volume is irrelevant. The expected profit depends on the price sensitivity or equivalently on the equilibrium bid ask spread.

Proposition 4.13: *The expected trading cost of liquidity traders, who have to trade an amount u which is known to them but not to the market, is*

(7.3) $$E\left[\tilde{u}\left(R\,\tilde{S} - \tilde{x}\right) \mid \tilde{u}, \tilde{y}^* = y^*\right] = \lambda\,\tilde{u}^2,$$

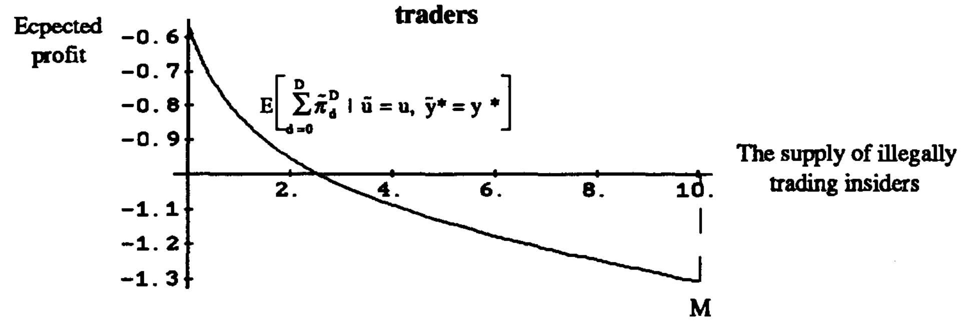
where the price sensitivity depends on insider trading such that

(7.4) $$\frac{d\,E\left[\tilde{u}\left(R\,\tilde{S} - \tilde{x}\right) \mid \tilde{u}, \tilde{y}^* = y^*\right]}{d\,\mu} > 0.$$

Proof: The trading cost follows straight away from the rule of conditional expectation. I substitute (7.1) into (2.3.8) and differentiate with respect to μ. The sign is given by (7.4). Q.E.D.

The expected welfare of noise traders who know that a liquidity event has occurred is falling in the supply of corporate insiders. Figure 8.9 illustrates.

FIGURE 4.9 Expected profit to uninformed traders



The trading cost increases monotonically from 0.566 towards infinity when the number of illegally trading insiders expands.

Corollary 4.10: *Suppose L is proposed to change from **A** to **B**, then the liquidity traders who do not know the size of their trade are against, and the liquidity traders knowing their liquidity demand are in favor.*

Proof: This follows from (7.2), (7.4), and the assumption than $\mu \leq M$. Q.E.D.

This means that the liquidity traders who do not know their future liquidity demand want to permit insider trading in order to limit their own trading.

7.2 Welfare of informed speculators

We have seen that the bid ask spread increases with the supply of corporate insiders, this has consequences for the expected welfare of informed speculators.

Proposition 4.14: *If σ is given by (7.1), the effect caused by insider trading on the welfare of informed speculators is*

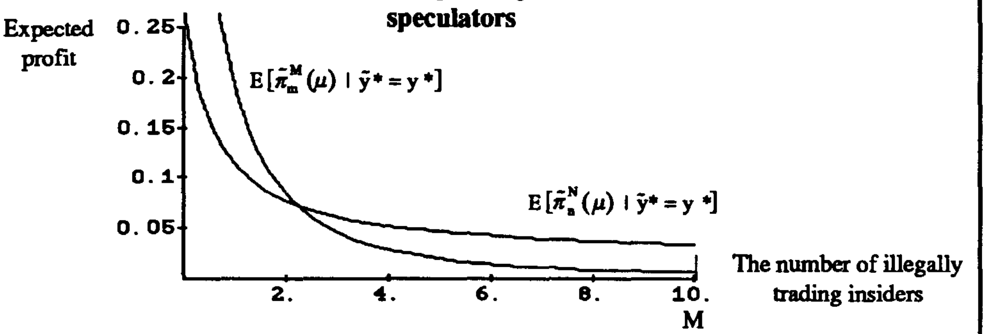
(7.6)
$$\frac{\mathrm{d}\,\mathrm{E}\left[\tilde{\pi}_{\mathrm{n}}^{\mathrm{N}}(\mu)\mid \tilde{y}^{*}=y^{*}\right]}{\mathrm{d}\,\mu} < 0, \textit{ and}$$

(7.7)
$$\frac{\mathrm{d}\,\mathrm{E}\left[\tilde{\pi}_{\mathrm{m}}^{\mathrm{M}}(\mu)\mid \tilde{y}^{*}=y^{*}\right]}{\mathrm{d}\,\mu} < 0.$$

Proof: I insert (7.1) into (2.2) and (2.3) and differentiate with respect to μ. The signs are given by (7.6) and (7.7). Q.E.D.

Figure 8.10 illustrates.

FIGURE 4.10 Expected profit to informed speculators



The expected profit decreases towards zero since the depth and thereby the liquidity converges toward zero. Thus, this is an example where the market shuts down at the limit due the fact that the corporate insiders are too numerous, and there will be no bid and ask prices at which trading can occur; see Glosten and Milgrom (1985) and Glosten (1989) for a similar result.

4.8 MARKET PROFESSIONALS VS LIQUIDITY TRADERS

The next proposition compares the liquidity traders attitude towards insider trading with the attitude of the market professionals.

Proposition 4.15: *There might be a conflict of interests between the two types of outsiders. For instance, the liquidity traders might prefer insider trading allowed when the market professionals prefer insider trading prohibited.*

Proof: If $M > M^{\bullet}$, the liquidity traders prefer $L = \mathbf{A}$ to $L = \mathbf{B}$. If the enforcement is complete, the market professionals prefer $L = \mathbf{B}$ to $L = \mathbf{A}$, but if the enforcement is incomplete, $L = \mathbf{A}$ might also be preferred by the professionals. Q.E.D.

The market professional such as security analysts are usually a well defined group of individuals with relatively strong organizations to promote their interests vis-à-vis the stock market authorities. On the contrary, the uninformed liquidity traders are usually a rather diverse group of individuals who might have rather weak organizations. Needless to say, the small uninformed might easily lose if there is a conflict of interests (see section 5.5).

4.9 SHORT SUMMARY OF SOME MAJOR CONCLUSIONS

The following effects are caused by insider trading on the expected welfare of the various types of traders on a stock market exchange where the superiorly informed speculators operate as price or information manipulators in the same way as in Kyle (1984, 1985):

- If the stock market regulators are instructed to prevent security traders from trading on inside information, the corporate insiders would of course lower their expectations of future returns from trading. But if the insiders expect a small risk of detection (e.g., because of inadequate enforcement or the camouflage provided by the outsiders), some of them may actually prefer insider trading outlawed.

This is because breaking the law may increase the market power and thereby the expected profit.

- If their supply is inelastic, the market professionals favor a law which prevents the corporate insiders from trading because of reduced competition. However, this is not necessarily the case if the enforcement of the law is inadequate. Trading with a few and powerful insiders reduces the welfare of the professionals because the illegally trading insiders have a greater market power than several insiders trading legally.
- Discretionary liquidity traders minimize their trading cost by trading in periods, markets, and securities where the adverse selection component in the equilibrium bid ask spread is expected to be the least. This may lead to two types of equilibria: As expected, the discretionary liquidity traders tend to concentrate their trades in securities where insider trading is forbidden, or, more surprisingly, in securities where the corporate insiders are very active. The worst case seems to be trading in securities or periods where a small number of insiders are trading (perhaps illegally), and therefore have a large price manipulative power.

Chapters 7 - 8 extend this analysis by introducing risk aversion, and market power in the broker - dealership market.

APPENDICES

This section proves lemma 4.1 and 4.2. Both proofs are based on the stock market equilibrium given by lemma 2.1.

Appendix A Proof of lemma 4.1

At time t_2, the expected profit of corporate insider $m \in \{1, 2, ..., M\}$ is

$$\text{(A1)}\quad E\left[\tilde{\Delta}_m \left(\tilde{x} - R\tilde{S}\right) \mid \tilde{y}^* = y^*\right] = \underbrace{E\left[\tilde{\Delta}_m \mid \tilde{y}^* = y^*\right] E\left[\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right]}_{=0} + \operatorname{cov}\left(\tilde{\Delta}_m, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right),$$

or, after inserting the price function given by (2.3.7),

$$\text{(A2)} \qquad E\left[\tilde{\Delta}_m \left(\tilde{x} - R\tilde{S}\right) \mid \tilde{y}^* = y^*\right] = \operatorname{cov}\left(\tilde{\Delta}_m, \tilde{x} \mid \tilde{y}^* = y^*\right) - \lambda \operatorname{cov}\left(\tilde{\Delta}_m, \tilde{z} \mid \tilde{y}^* = y^*\right).$$

Then I substitute in the insider's trading strategy given by (2.3.2) and the net order flow given by (2.A31). The result is

$$\text{(A3)} \qquad E\left[\tilde{\Delta}_m \left(\tilde{x} - R\tilde{S}\right) \mid \tilde{y}^* = y^*\right] = \alpha\beta\left[\Gamma - \beta\lambda\left\{(N + M\alpha)\Gamma + M\alpha\eta\right\}\right].$$

Finally, I insert the trading intensity given by (2.3.3) and the price sensitivity given by (2.3.8), and yield (2.2) after some straightforward simplifications.

In the same way, at time t_{-2}, professional $n \in \{1, 2, ..., N\}$ expects to earn a profit (before acquisition costs)

$$\text{(A4)} \qquad E\left[\tilde{\theta}_n \left(\tilde{x} - R\tilde{S}\right) \mid \tilde{y}^* = y^*\right] = \beta\left[\Gamma - \beta\lambda\left\{(N + M\alpha)\Gamma + N\varepsilon\right\}\right].$$

I insert (2.3.3) and (2.3.8), and yield (2.3). This completes the proof of lemma 4.1.

Appendix B Proof of lemma 4.2

The expected profit of the liquidity traders is

$$\text{(B1)} \quad E\left[\tilde{u}\left(\tilde{x} - R\tilde{S}\right) \mid \tilde{y}^* = y^*\right] = \underbrace{E[\tilde{u} \mid \tilde{y}^* = y^*]\, E\left[\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right]}_{=0} + \operatorname{cov}\left(\tilde{u}, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)$$

$$= \underbrace{\operatorname{cov}(\tilde{u}, \tilde{x} \mid \tilde{y}^* = y^*)}_{=0} - \lambda \operatorname{cov}(\tilde{u}, \tilde{z} \mid \tilde{y}^* = y^*) = -\lambda\sigma.$$

The next step is to insert the price sensitivity given by (2.3.8). The result is given by (2.9). This completes the proof of lemma 4.2.

REFERENCES

Admati, A., and P. Pfleiderer, 1988, "A Theory of Intraday Patterns: Volume and Price Variability," Review of Financial Studies, 3 - 40.

Charlton, D. W., and D. R. Fischel, 1983, "The Regulation of Insider Trading," Stanford Law Review, 857 - 895.

Chowdhry, B., and V. Nanda, 1991, "Multi-Market Trading and Market Liquidity," Review of Financial Studies, 483 - 511.

Dennert, J., 1991, "Insider Trading," Kyklos, 181 - 202.

Fishman, M. J., and K. M. Hagerty, 1992, "Insider Trading and the Efficiency of Stock Prices," Rand Journal of Economics, 106 - 122.

Foster, F. D., and S. Viswanathan, 1990, "A Theory of the Interday Variations in Volume, Variances, and Trading Costs in Securities Markets," Review of Financial Studies, 593 - 624.

Fudenberg, D., and J. Tirole, 1991, "Game Theory," MIT-Press.

Glosten, L. R., 1989, "Insider Trading, Liquidity, and the Role of the Monopolist Specialist," Journal of Business, 211 - 235.

Glosten, L. R., and P. R. Milgrom, 1985, "Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders," Journal of Financial Economics, 71 - 100.

Kyle, A. S., 1984, "Market Structure, Information, Futures Markets, and Price Formation," In G. G. Storey, A. Schmitz, and A. H. Sarris, eds., "International Agricultural Trade: Advanced Reading in Price Formation, Market Structure, and Price Instability," Westview-Press, 45 - 65.

Kyle, A. S., 1985, "Continuous Auctions and Insider Trading," Econometrica, 1315 - 1335.

Leland, H. E., 1992, "Insider Trading: Should It Be Prohibited?" Journal of Political Economy, 859 - 887.

Pagano, M., 1989, "Trading Volume and Asset Liquidity," Quarterly Journal of Economics, 255 - 274.

Subrahmanyam, A., 1991, "A Theory of Trading in Stock Index Futures," Review of Financial Studies, 17 - 51.

SYMBOL GLOSSARY

OF PART II

a	62
$\mathbf{a}$	58
α	51, 81
$\alpha`$	54, 55
$\boldsymbol{\alpha}$	129
$\mathbf{A}$	47
A	61, 62
b	58
β	51, 58
B	51
$\mathbf{B}$	47
C	103, 104, 138
$\mathrm{cov}(\, , \mid)$	49
d	46, 140
$\mathbf{d}, \mathbf{d}_\tau$	41, 42
δ	42
D	46, 140
ΔN^*	106
$\Delta N_{\Delta\beta=0}, \Delta N_{\Delta\lambda=0}, \Delta N_{\Delta\Psi=0}$	106, 108, 109
Δ_m	45, 50, 58
e	56
e_n	44
ε	44
E	48
$E[\mid]$	45
ϕ	56
Φ	56, 58
g	42
γ	42
Γ	51
$\mathbf{h}$	43
η	43
i	57
ι	57
j	56
φ	56
k	41
K, K_t	41
λ	49, 51, 58
$\lambda^\cdot$	63, 64
L	47
Λ_a	62
m	43, 45

PART III

PRODUCTION

CHAPTER 5

ON PRODUCTION, DISCLOSURE, AND INSIDER TRADING REGULATIONS

First draft: February 1991,

Current revision: January 1993.

ABSTRACT

A change in the supply of corporate insiders is shown to affect the expected welfare of current shareholders by causing information, production, and enforcement cost effects. My analysis indicates that if the negative production effect is very strong, it quickly tends to dominate the positive information and cost effects. In such a market, I conclude that insider trading is not desirable as it gives corporate managers an incentive to act in their own interests and not in the interest of their principals. They do this by shirking their duty as suppliers of productive effort. In this way, insider trading is really an agency problem.

5.1 INTRODUCTION

I have in the previous chapter used the pure exchange economy characterized by lemma 2.1, and analyzed the welfare effects caused by a change in the supply of corporate insiders. The change was taken to be the result of exogenous regulation by the stock market regulators. In this chapter, I extend to a corresponding production and exchange economy where the enforcement of the regulation is determined as part of the equilibrium. This is done by recognizing that there are shareholders before trading takes place, and, if it is in their interests, they have incentives to limit insider trading either themselves or by demanding more control by the public enforcement agency.

The sequence of events is as follows. First, the corporate managers choose individually an unobservable effort either to maximize their own expected welfare or to maximize the welfare of current shareholders. The first type of managers is referred to as "disloyal" whereas the second type is "loyal". Then the "firm" determines the number of "disloyal" agents, the production of inside information, and the disclosure to the outsiders where the "firm" means a collective decision made by "loyal" managers. The next event is that the "disloyal" managers select their trading strategies, and present their orders to the market based on inside information. In the securities market, there are also market professionals and liquidity traders submitting orders to the price setting market makers as described in section 2.2. Finally, the payoff of the firm is realized and is therefore common knowledge. Within this framework, the expected welfare of current shareholders depends on the amount of insider trading:

(i) If the supply of trading insiders expands in one firm, the securities market becomes better informed about this firm's future prospects. In this way, its transaction price is a better predictor of the future value of the firm's securities, and thereby reveals more about the unobserved effort supplied by its employees. As in the agency literature (see, e.g., Holmström (1979)), better monitoring increases the effort which, of course, is beneficial to the shareholders as the expected value of their securities increases now and in the future. This effect is referred to as the information effect. It tends to be important if outside sources of information are of low quality, or if there are no disclosures from the firm.

(ii) There are two types of managers: Corporate insiders are here considered to be "disloyal" since they may not only trade illegally on inside information, but also find it optimal to supply less productive effort than the "loyal" managers. This effect on the total production is referred to as the production effect. It turns out to be important if many employees are trading illegally and there are small personal costs of shrinking. A different approach is chosen in the next chapter to more clearly describe the incentive effects of insider trading.

(iii) If some of the corporate managers are "allowed" to operate on superior internal information, less costs have to be spent by current shareholders to enforce the ban of insider trading. These costs are high if current shareholders want to effectively prevent corporate insiders from trading, resulting in no insiders in the financial market.

The trade-off between these three effects determines a unique number of corporate insiders which is "allowed" to trade illegally on inside information. Because of the enforcement cost and the revelation by insider trading, the optimal supply is seldom zero. However, the current shareholders have an incentive to limit insider trading because of the production effect, but they prefer the stock market authorities of doing it for them by imposing and enforcing a law prohibiting insider trading.

Public regulation and enforcement are desirable to current shareholders if there are cost advantages in public regulation and if enforcement or the costs are paid by the security traders, for instance, through an additional component in the equilibrium bid ask spread. I find that the optimally regulated supply of corporate insiders depends, among other things, on the exogenously specified welfare weights. If all individuals in the economy have the same welfare weights and there are no economics of scale in public regulation, the publicly determined supply would equal the privately determined supply of illegally trading insiders. Nonetheless, if some of the traders are over-represented in the welfare function, the publicly regulated supply of corporate insiders would be more or less than the privately regulated supply, depending on whether the favored group prefers insider trading allowed or not.

The "loyal" managers are assumed to determine the production of inside information and the disclosure to the public. They disclose information through the outside signals. On these issues, my model is close to Fishman and Hagerty (1989) who find that it is optimal for the firm to disclose or tip information to a limited number of outsiders. This may also be the case in my model, but instead I focus on production and disclosure of information to all the outsiders. Nonetheless, tipping of internal information may be a better alternative for current shareholder than insider trading because the shareholders avoid the negative production effect discussed above.

Public disclosure is studied, e.g., by Diamond (1985) who within a rational expectations framework shows that there might exist a policy of voluntary disclosure which makes all shareholders (there are no corporate insiders or market maker) better off than a policy of no disclosure because of explicit information cost savings and improved risk sharing.[1] This implies that the firms themselves have incentives to disclose internal information to the public. This conclusion holds even if the firms have some cost disadvantage in producing information, since disclosed information is perfectly perceived by outsiders rather than being "filtered" through a noisy price channel. Such effects are not recognized here, but the firms have, nevertheless, an incentive to disclose information because it is the current shareholders who have control of the firm and they benefit from public disclosures. These benefits come from the fact that disclosed information reduces their moral hazard (or hidden action) problem. This is consistent with findings in the principal - agent literature; see, e.g., Holmström (1979).

This chapter proceeds as follows. In the next section, the trading equilibrium given by lemma 2.1 is extended to a corresponding security market where, for a given precision of the price system, the corporate employees supply the effort expected of them by their principals. Section three analyzes how the expected effort is determined given the outlined assumptions, and analyzes its properties. The optimal number of managers maximizing their own welfare is determined in section four and five to maximize the welfare of current shareholders. The number of individuals maximizing their own welfare is assumed to coincide with the number of illegally trading insiders. In section five, the focus is on public regulation whereas, in section four, the focus is on private regulation. Section six looks at direct disclosure to the public as an alternative to disclosure through insider trading. The major conclusions are summarized in section seven. Some formal proofs are found in the appendices.

---

[1] See Bhattacharya (1989) part III for an excellent survey on disclosure and its regulation. Ross (1979), however, argues for and against government regulations and disclosure.

5.2 TRADING EQUILIBRIUM

I draw on the assumptions specified in section 2.2 and extend by taking into account that the corporate insiders supply a productive action or effort. This means that the value of security $k \in \{1, 2, ..., K\}$ at time $t+1 \in \{0, 1, ..., T_k-1\}$ is

$$(2.1) \qquad \tilde{x} + e \sim N(m_x + e, \delta).$$

where x is given by (2.2.2) and e is the net value of the managers' effort from time t to t+1. The term x is stochastic and may be interpreted as random business fluctuations outside the control of the corporate insiders, whereas the term e is deterministic and determined by the corporate managers prior to trading. Outsiders such as the current shareholders observe only the sum x + e, which means that they cannot ex post infer that the insiders actually have supplied the expected effort e. Nonetheless, the corporate insiders supply the effort they are expected to supply, but in the next chapter, they may make the effort uncertain and thereby generate superior information.

Lemma 5.1: *Suppose L = A, then there exists a unique, linear pooling of orders equilibrium $[(\theta_{nkt}, \Delta_{mkt}), S_{kt}; k \in \{1, 2, ..., K_t\}, t \in \{0, 1, ..., T_k-1\}, n \in \{1, 2, ..., N\}, m \in \{1, 2, ..., M\}]$ where the trading strategies of market professionals and corporate insiders are*

$$(2.2) \qquad \tilde{\theta}_n = \beta\left(\tilde{y}_n - E[\tilde{x} + e \mid \tilde{y}^* = y^*]\right), \textit{ and}$$

$$(2.3) \qquad \tilde{\Delta}_m = B\left(\tilde{y} - E[\tilde{x} + e \mid \tilde{y}^* = y^*]\right).$$

The trading intensities are

$$(2.4) \qquad \beta = \sqrt{\frac{\sigma}{N(\Gamma + \varepsilon) + M(\Gamma + \eta)\alpha^2}}, \textit{ and}$$

$$\text{(2.5)} \qquad B = \alpha\beta,$$

in which

$$\text{(2.6)} \qquad \Gamma = \frac{\delta\gamma}{\delta + \gamma}, \textit{ and}$$

$$\text{(2.7)} \qquad \alpha = \frac{\Gamma + 2\varepsilon}{\Gamma + (M + 1)\eta}.$$

The market price is set by market makers to earn zero expected profit in the dealership market, resulting in a transaction price

$$\text{(2.8)} \qquad \tilde{S} = \frac{1}{R}\left\{E[\tilde{x} + e \mid \tilde{y}^* = y^*] + \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m + \tilde{u}\right)\right\},$$

where the price sensitivity is

$$\text{(2.9)} \qquad \lambda = \frac{\Gamma}{N\Gamma + (M + 1)(\Gamma + \eta)\alpha}\sqrt{\frac{N(\Gamma + \varepsilon) + M(\Gamma + \eta)\alpha^2}{\sigma}}.$$

If $L = B$, then μ replaces M.

The proof mimics the proof of lemma 2.1 and is therefore omitted, everywhere $x + e$ replaces x. This means, for instance, that the private signals $y = x + e + h$ and $y_n = x + e + e_n$ are replacing the signals given by (2.2.6) and (2.2.8) and so on.

In the next chapter, I extend to a production and exchange economy where the corporate insiders may choose to supply an effort different from what is expected by the securities market; see lemma 6.1 for a concentrated characterization of the trading equilibrium. This means that by randomizing their selection of effort, the corporate insiders are able to produce inside information which generates an abnormal return when trading on it in the securities market.

Corollary 5.1: If $e = 0$, then lemma 5.1 equals lemma 2.1.

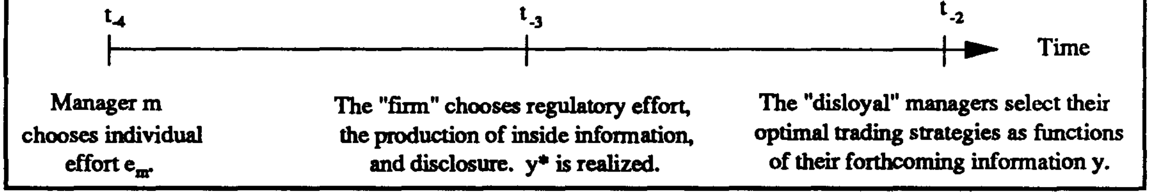
If there are no effort, then the outcome of the production process equals x. Therefore the payoff is only influenced by random business fluctuations, and so called insiders trade on a signal correlated with the business fluctuations and thereby generate abnormal returns (see chapters 2 - 4).

5.3 OPTIMAL EFFORT

The trading model characterized by lemma 5.1 takes a first step approaching a model which considers the corporate insiders as employees who have to supply some effort to justify their existence, but it does not explain how the employees choose their supply (see also lemma 2.2). This is the topic of this section. Later sections look at other managerial decisions such as production of information, disclosure, and regulation of insider trading by the firms themselves or by the public regulators.

Figure 5.1 combined with figure 2.1 illustrate the extended sequence of events taking into account the managers` choice of productive effort (time t_{-2} means just before time t_{-1}, time t_{-3} means just before time t_{-2}, and so on).

FIGURE 5.1 Time structure



At time t_{-4}, the managers in firm $k \in \{1, 2, ..., K\}$ choose an individual action (effort or investment) where time $t \in \{0, 1, ..., T_k-1\}$. Then at time t_{-3}, the corporate managers collectively choose the firm`s regulatory effort, the production of inside information, and the quality of the public disclosure. Finally, trading takes place from time $t_{-2}$ to t as described in section 2.2. The rest of this section gives the assumptions behind the managers` choices of individual effort (that is, the decisions taken individually at time t_{-4}), the other decisions (taken together at time t_3) are analyzed in sections 5.4 - 5.6.

Assumptions about effort

If insider trading is prohibited by a public law or by a private contract regulating the relationship between the agents and their principals, the M corporate managers in firm k can generally be separated into μ agents, or in some respect "disloyal" managers, and M - μ "loyal" managers where $0 \leq \mu \leq M$. The difference between these two types of corporate managers is that the "loyal" managers are assumed to maximize the welfare of current shareholders, whereas the "disloyal" managers are assumed to maximize their own welfare which includes profit from insider trading. In sections 5.4 - 5.5, the number of "disloyal" managers is determined by the "loyal" managers' enforcement of the private contract between agents and principals or alternatively by the public regulatory agency.

I assume that M corporate managers are employed by the current shareholders of firm k and are, from time t to t+1, supposed as part of their contract to supply a productive effort. The total supply of effort from the managers is

$$(3.1) \qquad e = \sum_{m=1}^{M} e_m,$$

where e_m is the individual effort supplied by manager $m \in \{1, 2, ..., M\}$. The individual effort is determined according to the objectives of the M - μ "loyal" and the μ "disloyal" managers. It is only observable to the supplier (moral hazard). Nevertheless, e is imperfectly inferred through the security price or the future value of the security which means that if the price informativeness is high, the corporate managers have an incentive to supply a high effort. The individual effort e_m can be supplied by a "loyal" or a "disloyal" agent, and the principals cannot tell whether a particular manager is "loyal" or "disloyal". The individual effort and thereby the total effort are never randomized.

I assume that the individual supply of effort in firm k in the period from t to t+1 is costly and given by a quadratic cost function

$$
(3.2) \qquad C(e_m) = \begin{cases} \frac{c}{2}\, e_m^2 & \text{if } m \in \{1, 2, \ldots, M - \mu\}, \text{ and} \\ \frac{1}{2}\left[c\, e_m^2 + \mathbf{c}\left(e_m - e_m^*\right)^2\right] & \text{if } m \in \{1, 2, \ldots, \mu\}, \end{cases}
$$

where $c > 0$, $\mathbf{c} \geq 0$, and e^*_m is the effort supplied by the "loyal" managers. This implies that because $c > 0$, it is costly to supply effort, and if, in addition, $\mathbf{c} > 0$, the "disloyal" managers feel it as a burden to supply an effort different from what the "loyal" managers supply. The first-derivative $d\,C(e_m) / d\,e_m = c\,e_m + \mathbf{c}\,(e_m - c^*_m) > 0$ and the second-derivative $d^2\,C(e_m) / d\,e_m{}^2 = c + \mathbf{c} > 0$, which means that the cost function is increasing and convex.

The problem of a "loyal" manager $m \in \{1, 2, \ldots, M - \mu\}$ is to choose an effort at time t_4 which maximizes the expected welfare of current shareholders. That is,

$$
(3.3) \qquad \underset{e_m \geq 0}{\text{Max}} \; E\left[\tilde{S}(e_m) \mid e_m\right] - \frac{1}{R} C(e_m),
$$

where $S(e_m)$ is the market value of firm k at time t as a function of individual effort (see (2.8)) and $C(e_m)$ is the individual cost if the effort e_m is chosen by the "loyal" manager. Managers maximizing (3.3) are called myopic or short-sighted.

Definition 5.1: *An optimal individual effort of "loyal" managers maximizing (3.3) is an effort* $e^*_m > 0$ *such that* $E[S(e^*_m)] - C(e^*_m) \geq E[S(e'_m)] - C(e'_m)$ *for all* $e'_m \in [0, \infty)$.

An alternative objective for the principals is to instruct the "loyal" managers to maximize the future value of the firm (that is, x + e which is the value at time t+1), and not the current value represented by the value of the shares determined by the market makers at time t. Thus,

$$
(3.4) \qquad \underset{e_m \geq 0}{\text{Max}} \; \frac{1}{R}\left\{E\left[\tilde{x} + e_m + \sum_{m=1}^{M-1} e_m \mid e_m\right] - C(e_m)\right\},
$$

where the individual cost function is given by (3.2). Conditioned e_m means that at time t_{-4} the "loyal" manager knows his effort, but have no other information except the common knowledge about the structure of the equilibrium. Managers maximizing (3.4) are called far-sighted.

Definition 5.2: *An optimal individual effort of "loyal" managers maximizing (3.4) is an effort* $e^{**}_m > 0$ *such that* $E[x + e^{**}_m + \Sigma e_m] - C(e^{**}_m) \geq E[x + e'_m + \Sigma e_m] - C(e'_m)$ *for all* $e'_m \in [0, \infty)$.

This choice of effort is first best efficient (or Pareto-optimal) because the marginal long-term revenue equals the marginal cost of effort.

The compensation paid to the managers for their supply of individual effort at time t+1 has to be financed. If the value of firm k is paid out each period as dividend, the dividend $\mathbf{d}_t$ earned in the period from t-1 to t is paid out at time t (see (2.2.2)). I assume, nevertheless, that a fraction of this amount is used to pay the corporate managers $(M / R)\ C(e^*_m)$ (or $(M / R)\ C(e^{**}_m)$) to compensate for their individual supply of effort. Notice that the principals pay each of the managers the cost of supplying the for them optimal effort since all managers are claiming to maximize the welfare of current shareholders. Then if there are no other investments, the rest $\mathbf{d}_t$ - $(M / R)\ C(e^*_m)$ is paid out as dividend at time t. This means that S is the net value of firm k at time t (after the dividend is paid out) since $(M / R)\ C(e^*_m)$ is sunk.

The problem of the "disloyal" managers is to determine an individual effort e_m which at time t_{-4} maximizes their own expected profit:

$$(3.5) \qquad \underset{e_m \geq 0}{\text{Max}}\ \frac{1}{R}\left\{E[\tilde{\pi}^{\mu}_m] + C\left(e^*_m\right) - C\left(e_m\right)\right\},$$

where $E[\pi_m{}^{\mu} \mid e_m]$ is the expected profit from insider trading, $C(e^*_m)$ is the compensation which the insider is paid by the principals by claiming that he has produced an effort to maximize their welfare, and the last term $C(e_m)$ is the actual cost of supplying an effort e_m which, of course, may differ from the optimal effort e^*_m.

Definition 5.3: *An optimal individual effort of "disloyal" managers maximizing (3.5) is denoted* $e^{\bullet}_m > 0$ *and is determined such that* $E[\pi_m{}^{\mu}] + [C(e^*_m) - C(e^{\bullet}_m)] \geq E[\pi_m{}^{\mu}] + [C(e^*_m) - C(e'_m)]$ *for all* $e'_m \in [0, \infty)$.

I have implicitly assumed that the number of "disloyal" managers equals the number of illegally trading insiders. In this way, there is a strong link between insider trading and the harm caused by "disloyal" managers which, as we shall see, creates a strong negative production effect. This strong link may be criticized because in this model there is no good explanation why managers should stop being agents because they are forced to stop their trading activity. This means that the production effect exists by assumption and is not a result of the model.

Optimal choice of effort

The managers` choice of effort is determined to maximize their effort-selection problems given by (3.3) or (3.4) and (3.5).

Lemma 5.2: *If the "loyal" managers are instructed to be myopic and the stock market equilibrium is given by lemma 5.1 where μ corporate insiders trade illegally, then the optimal individual effort of a "loyal" manager $m \in \{1, 2, ..., M - \mu\}$ is*

$$(3.6) \qquad e_m^* = \frac{1}{c}\left[1 - \frac{1}{\delta\Psi}\right].$$

where the price efficiency

$$(3.7) \qquad \Psi = \frac{1}{\delta} + \frac{1}{\gamma} + \frac{N(\delta + \gamma)}{\delta\gamma + 2\,\varepsilon(\delta + \gamma)} + \frac{\mu(\delta + \gamma)}{\delta\gamma + (\mu + 1)\,\eta(\delta + \gamma)}.$$

Let Ψ^* be the efficiency when the price is a sufficient informational statistic (see (3.5.11)), then $\Psi \leq \Psi^*$. The individual effort of a "disloyal" manager $m \in \{1, 2, ..., \mu\}$ is

$$(3.8) \qquad e_m^{\bullet} = \frac{c}{c + c}\, e_m^*.$$

The total effort e is in optimum

$$(3.9) \qquad e^* = \frac{1}{c}\left[M - \frac{c}{c + c}\mu\right]\left[1 - \frac{1}{\delta\Psi}\right].$$

The expected value of firm k at time t_{-4} is

$$(3.10) \qquad V^* = \frac{1}{R}\left\{m_x + \frac{1}{c}\left[1 - \frac{1}{\delta\Psi}\right]\left\{\frac{1}{2}\left(1 + \frac{1}{\delta\Psi}\right)M - \frac{c}{c + c}\mu\right\}\right\},$$

where m_x is the unconditional expectation of x.

Proof: See appendix A.

This lemma extends part II in Fishman and Hagerty (1989) to a market in which some of the corporate managers may trade illegally on inside information (see corollary 5.4 below). In lemmas 6.2 - 6.4, a different approach is chosen where the corporate insiders are able to supply an effort different from what is expected by the market, and thereby produce superior information about effort which generates a positive expected profit in the securities market.

The market price given by (2.8) reveals information about effort. At time t_{-4}, the market has its initial conjecture about effort. Then at time t_{-3}, a public signal reveals information about effort, and the market revises its expectation. Finally, when the traders trade at time t_{-1} submit their orders, the market makers observe the order flow. The orders are partly based on superior information, but the market makers revise their expectation about effort so that it is not possible to earn money on information about effort (see (A6)).

Special cases

The next to corollaries gives the effort and the value of the firm when the price reflects this information perfectly and when the price does not reflect any information about effort at all.

Corollary 5.2: If the "loyal" managers are far-sighted, the individual effort, the total effort, and the value of the firm are

$$(3.11) \qquad e_m^{**} = \frac{1}{c},\ e^{**} = \frac{1}{c}\left\{M - \frac{c}{c + c}\mu\right\},\ \textit{and}\ V^{**} = \frac{1}{R}\left\{m_x + \frac{1}{c}\left\{\frac{1}{2}M - \frac{c}{c + c}\mu\right\}\right\},$$

respectively. Suppose $\Psi \to \infty$ (which means that the transaction price reflects perfect information), then there is no difference between shortsighted and far-sighted managers, both types of managers supply an effort resulting in (3.11).

Proof: The individual effort of far-sighted managers is given by (A2). The total effort and the value of the firm follow easily from the individual effort. If $\Psi \to \infty$ (which happens, e.g., if $N \to \infty$), the market price equals the liquidating value of the security realized at time t+1. This is because if the order flow reflects perfect information about the future value of the security, $E[x + e \mid z, y^*=y^*] = x + e$. In this case the optimal individual effort is given by the limit of (3.6) when $\Psi \to \infty$. This implies that the total effort and the expected value of the firm are the corresponding limits of (3.9) and (3.10). Q.E.D.

Far-sighted managers maximize the expected value of the firm at time t+1 whereas the myopic managers maximize the value at time t. If the market price reflects perfect information about the future value of the security, the two maximization problems are identical and must therefore give the same choice of effort and the same expected value of the firm. The corollary looks at the other extreme.

Corollary 5.3: If $\Psi = 1 / \delta$ (which means that the market price reflects no information), there is no productive effort by the managers and the present expected value of the firm equals $(1 / R)\ m_x$.

Proof: This follows directly from (3.6) - (3.10). Q.E.D.

If the market price does not reflect any information, the "loyal" managers minimize the cost of supplying effort which means that $e^* = 0$. The security price is not taken into consideration because a positive effort give no positive effect on the security price. I mentioned above that Fishman and Hagerty (1989) is a special case of the model presented here, the next corollary emphasizes the differences.

Corollary 5.4: If the "loyal" manager is shortsighted (this implies that $M = 1$), $m_x = \mu = 0$, $\gamma \to \infty$, and $R = 1$, then

$$(3.12)\quad e^* = \frac{N\delta}{c\left[(N+1)\delta + 2\varepsilon\right]} \text{ and } V^* = \frac{N\delta}{c\left[(N+1)\delta + 2\varepsilon\right]}\left[1 - \frac{N\delta}{2\left[(N+1)\delta + 2\varepsilon\right]}\right].$$

Proof: This follows directly from (3.9) and (3.10). Q.E.D.

This total effort is almost equal to the total effort in Fishman and Hagerty (1989); see their example on page 641. The difference is caused by the fact that Fishman and Hagerty's informed outsiders (who are market professionals) observe common and not diverse information (which means that $(N + 1)(\delta + \varepsilon)$ replaces $[(N + 1)\delta + 2\varepsilon]$ in (3.12)).

On the properties of the optimal choice of effort

This subsection discusses some of the most interesting properties of lemma 5.2 regarding the managers' choice of effort.

Proposition 5.1: If $\Psi < \infty$, then

$$(3.13)\qquad V(\,\cdot \mid \text{myopic managers}) < V(\,\cdot \mid \text{far-sighted managers}).$$

Proof: The net value of the firm to current shareholders is given by (3.10) when the corporate managers are myopic, and by $\lim_{\Psi \to \infty} V(\Psi)$ when the managers are far-sighted (see corollary 5.2). We see directly from (3.10) that if $\Psi < \infty$, then $V(\mu)$ is less than its limit when the price informativeness approaches infinity. Q.E.D.

The expected liquidating value of the firm is highest if the corporate managers are instructed to be far-sighted and maximize the expected net value of the firm at time t+1. The reason is that the market price is a noisy predictor of the future value, and it is, of course, best to use the future value itself.

Proposition 5.2:

$$\frac{dV}{dc} < 0 \text{ and } \frac{dV}{d\Psi} > 0. \tag{3.14}$$

Proof: This follows by differentiating (3.10) with respect to the relevant variables. Q.E.D

The expected value of the firm decreases with the cost of making effort and increases with the price informativeness.

5.4 PRIVATE REGULATION

At time t_{-3}, the "loyal" managers meet and decide the number of "disloyal" managers by maximizing the value of firm k after taking into account the firm's cost of limiting the number of "disloyal" managers. Thus, μ^* is a solution to

$$\underset{0 \le \mu \le M}{\text{Max}} \; V(\mu) - \frac{1}{R} C(\mu), \tag{4.1}$$

where the firm's cost function is assumed to be of the type

(4.2) $$C(\mu) = \frac{k}{2}(M - \mu)^2.$$

I assume that $k \geq 0$ and the cost function therefore decreases with $\mu \leq M$ (because $d\,C(\mu) / d\,\mu = - k\,(M - \mu) < 0$). It is more costly for large firms to effectively prohibit insider trading than smaller firms because $C(\mu)$ increases with M which is the total number of employees in the firm and therefore a measure of firm size. The cost is financed in the same way as $M\,C(e^*_m)$; see section 5.3.

Definition 5.4: *An optimal supply of "disloyal" managers μ^* is a supply such that $V(\mu^*) - C(\mu^*) \geq V(\mu') - C(\mu')$ for all $\mu' \in [0, M]$.*

The next lemma characterizes the optimal supply:

Lemma 5.3: *The optimal supply of "disloyal" managers, denoted μ^*, is determined by maximizing (4.1), or as a solution to the condition*

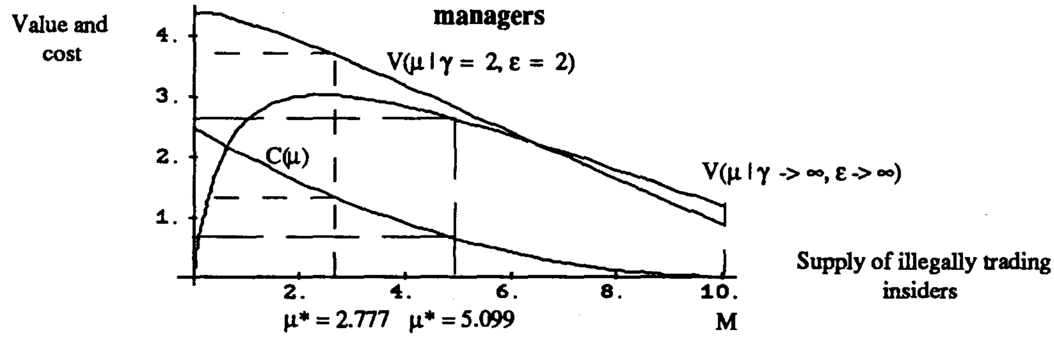
(4.3) $$\frac{1}{c}\left\{\frac{1}{\delta\,\Psi^2}\left[\frac{c\,\mu}{c + c} - \frac{M}{\delta\,\Psi}\right]\frac{d\,\Psi}{d\,\mu} + \left[1 - \frac{1}{\delta\Psi}\right]\frac{c}{c + c}\right\} - k\,(M - \mu) = 0,$$

where

(4.4) $$\frac{d\,\Psi}{d\,\mu} = \frac{(\delta + \gamma)\left[\delta\,\gamma + (\delta + \gamma)\,\eta\right]}{\left[\delta\,\gamma + (\mu + 1)\,(\delta + \gamma)\,\eta\right]^2}.$$

Proof: Condition (4.3) is the first order condition of (4.1), and (4.4) follows straightforwardly from (3.7). Q.E.D.

Figure 5.2 illustrates two cases where the "disloyal" managers choose unique solutions. I have used the numerical values given in table 5.2 (see appendix C) if not specified otherwise.



If information is disclosed, $\mu^* = 2.777$, and the net value of the firm is 2.339. If illegal insider trading is the sole method of disclosing information, $\mu^* = 5.099$, and the net value of the firm is 1.999. Thus, if there are other methods for disclosing information than insider trading, the optimal supply of illegally trading insiders tends to be less and the net value of the firm tends to be higher.

There are according to (4.3) three effects which the "loyal" managers have to take into account when they determine the optimal supply of "disloyal" managers: First, if $c < \infty$, then, according to (3.8), the "disloyal" managers produce less than the "loyal" managers. Notice that if $c = 0$, the "disloyal" managers do not supply any effort at all. This means that if μ increases, more managers becomes "disloyal" and the total production and thereby the value of the firm decreases. This effect is called the production effect. If $\Psi < \Psi^*$ and μ is increasing, then, according to (3.7), (3.9), and (3.10), there is a positive effect on the supply of effort and thereby on the value of the firm. This effect is called the information effect. Finally, if $k > 0$, it is cost-saving to increase the number of "disloyal" managers which means that there is an effect increasing the value of the firm. This effect is referred to as the cost effect. Table 5.1 summarizes the effects.

TABLE 5.1: Effects on value caused by $\Delta\mu$

$\Delta\mu$	Pe	Ie	Ce	Total effect
$\mu \in [0, \mu_V]$	-	+	+	+/(-)
$\mu \in (\mu_V, M]$	-	+	+	- /(+)

Pe = Production effect, Ie = Information effect, Ce = Cost effect, and μ_V is a constant.

The net value of the firm as a function of the number of "disloyal" managers tends to increase and then decrease, suggesting that $0 < \mu^* < M$ as in the figure above. But the net value may be increasing or decreasing for all $\mu \leq M$.

Corollary 5.5: *Suppose $\Psi \rightarrow \infty$, then*

$$\mu^* = M - \frac{1}{\mathbf{k}\,(c + \mathbf{c})} \geq 0. \tag{4.5}$$

Proof: This follows easily from (4.3). If the μ given by (4.5) is negative, then $\mu^* = 0$. Q.E.D.

If the "loyal" managers are far-sighted, they reduce the supply of "disloyal" managers because they supply less effort than "loyal" managers, and not because they are potential insiders. We see that if $\mathbf{k}$, c, or $\mathbf{c} \rightarrow \infty$, $\mu^* = M$. On the other hand, if the "loyal" managers are myopic, no closed form solution exists for μ^*.

Proposition 5.3: *If $k \leq k'$ and $\Psi \geq \Psi'$, $\mu^* = 0$. On the contrary, if $k > k''$ and/or $c > c'$, $\mu^* = M$ Otherwise, $0 < \mu^* < M$.*

Proof: Clearly, the problem given by (4.1) is continuous. If $\Psi \rightarrow \infty$ and $\mathbf{k} = 0$, then according to (4.5), $\mu^* = 0$. Now let $\mathbf{k}' \geq 0$ be the largest $\mathbf{k}$ where $\mu^* = 0$, and let at the same time $\Psi' \leq \infty$ be the lowest Ψ where $\mu^* = 0$. If $\mathbf{k} \rightarrow \infty$, then $\mu^* = M$ since otherwise the cost of enforcement is infinite. Let $\mathbf{k}''$ be the lowest $\mathbf{k}$ where $\mu^* = M$. Finally, if $\mathbf{c} \rightarrow \infty$, then $\mu^* = M$ because, according to (3.8) all the managers are "loyal" and there is no negative production effect. Now let $\mathbf{c}'$ be the lowest $\mathbf{c}$ where $\mu^* = M$. Q.E.D.

Insider trading is effectively prohibited if there is no cost of enforcing the law and if insider trading is not needed to disclose information about effort. On the other hand, insider trading is allowed if the cost of enforcement is high and the insiders otherwise act almost as "loyal" managers.

5.5 PUBLIC REGULATIONS

I have so far assumed that there is a privately enforceable contract which regulates what the employees in firm k are supposed to do. Roughly speaking, they should maximize the expected welfare of current shareholders. There are two ways of organizing the enforcement:

- A private employment contract means that the employers and the employees agree on what the employees should or should no do. The control or enforcement of the contract could be delegated to the "loyal" employees or to a control committee appointed by the current shareholders. In this way, the enforcement should maximize their welfare.
- In addition to the private contracts, there could be a set of universal contracts which are best enforced by a governmental agency. Such public contracts or laws may be optimal, for instance, if there are economics of scale in regulation and enforcement, or if something is considered inappropriate in the view of the society.

Usually the relationship between agents and principals is regulated by a combination of both private and public contracts.

I assume that there exists a governmental agency (like the Securities and Exchange Commission in USA) whose duty it is to enforce the financial market regulations which are viewed as socially desirable. The government considers insider trading inappropriate and has consequently made it illegal. The enforcement agency is instructed to enforce the law to maximize a social welfare function given exogenously by the political bodies. Nevertheless, the agency does not prevent all insiders from trading as this regulatory strategy is too costly.

Regulation and enforcement are costly. The private cost of enforcement is given by (4.2), and the public cost is given by a similar cost function:

$$K(\mu) = \frac{K}{2}(M - \mu)^2, \tag{5.1}$$

where $K \geq 0$. If the governmental agency uses an amount of money $K(\mu)$, it reduces the number of corporate insiders operating on internal information from M to μ where $0 \leq \mu \leq M$. The gain is hopefully increased social welfare. Nevertheless, the amount used by the regulatory agency to limit the supply of corporate insiders has to be financed. I look at two methods:

- The companies listed on the stock exchange have to pay a fee $K(\mu)$ to the exchange or directly to the agency to cover the cost of enforcement.
- The security traders have to pay an additional component in the bid ask spread which ultimately is used to cover the enforcement costs.

There may, of course, be a combination of a fee paid by the current shareholders and an additional component in the equilibrium bid ask spread paid by the security traders. Other methods of financing law enforcement is also possible.

Financing through a fee

If the companies have to pay a fee depending on the desired level of enforcement, the optimal public enforcement of the insider trading law, denoted μ^{**}, is determined in the same way as μ^* in section 5.4.

Proposition 5.4: *If $k \geq K$ (public enforcement is cheaper than private enforcement, holding other parameters constant), then μ^* tends to be larger than μ^{**}.*

<u>Proof</u>: First, μ^* is determined by (4.3), and μ^{**} is determined by (4.3) where **k** is replaced by **K**. If **k** $\geq$ **K**, then $d\,V(\mu^*) / d\,\mu - d\,C(\mu^*) / d\,\mu = 0$ and $d\,V(\mu^*) / d\,\mu - d\,K(\mu^*) / d\,\mu > 0$. This means that in order to obtain $d\,V(\mu^{**}) / d\,\mu - d\,K(\mu^{**}) / d\,\mu = 0$, μ^{**} has to be less than μ^*. The reason is that my numerical analyses show that the net value of the firm falls with μ when $\mu > \mu^*$. A more general proof is difficult partly because there are no close form solutions for μ^* and μ^{**}. Q.E.D.

Economics of scale may make public enforcement less costly than private enforcement. Then the number of corporate insiders which is "permitted" to trade illegally is larger if the law or contract is enforced by the private firms themselves than by the governmental agency.

Financing through the bid ask spread

I am now turning to the other case in which the enforcement of the law is financed by an additional component in the equilibrium bid ask spread.

Lemma 5.4: *Suppose the price setting market makers expect to earn a positive profit which goes to cover $K(\mu) \geq 0$, then there exists a unique, linear quotation driven security market equilibrium $[(\theta_{nkt}, \Delta_{mkt}), S_{kt};\ k \in \{1, 2, ..., K\}, t \in \{0, 1, ..., T_k\text{-}1\}, n \in \{1, 2, ..., N\}, m \in \{1, 2, ..., M\}]$ of the same structure as lemma 5.1. The trading intensities are*

$$\text{(5.2)} \qquad B = \alpha\beta, \text{ and}$$

$$\text{(5.3)} \qquad \beta = \frac{\Gamma}{[N\Gamma + (\mu + 1)(\Gamma + \eta)\alpha]\lambda},$$

where the price sensitivity is

$$\text{(5.4)} \qquad \lambda = \frac{K(M - \mu)^2}{2\sigma} + \sqrt{\left(\frac{K(M - \mu)^2}{2\sigma}\right)^2 + \frac{[N(\Gamma + \varepsilon) + \mu(\Gamma + \eta)\alpha^2]\Gamma^2}{[N\Gamma + (\mu + 1)(\Gamma + \eta)\alpha]^2\sigma}}.$$

Proof: See appendix B.

Lemma 5.4 extends lemma 5.1 to a quotation driven equilibrium where the price setting market makers earn a positive expected profit. I have not found any extension of the Kyle type models allowing market makers to earn a fixed return other than zero. However, the cost component in the bid ask spread is recognized in the market microstructure literature; see, e.g., Stoll (1985), pages 79 - 80. The next corollary follows directly from the lemma.

Corollary 5.6: *If $K = 0$ or $L = A$, lemma 5.4 is identical to lemma 5.1.*

In lemma 5.1 the price setting market makers expect, before the net order flow is actually realized, to earn zero profit for every realization of the order flow (see (2.2.15)), whereas in lemma 5.4 they earn on average a positive revenue which goes to cover $K(\mu) \geq 0$.

If $z^2 > var(z \mid y^*=y^*)$, the market makers actually earn more than $K(\mu)$, but if the order flow $z^2 < var(z \mid y^*=y^*)$, they earn less. The market makers quote the bid ask spread before they observe the net order flow and have to stick to the bids and asks after they observe the incoming orders; see Admati and Pfleiderer (1989) for a similar market where orders arrive one by one. A securities market of this type is called quotation driven. On the contrary, a securities market where the market makers set the equilibrium bid ask spread after they have observed the net order flow is called order driven. Lemma 5.1 may both be interpreted as quotation or order driven.

Proposition 5.5: *For a given supply of corporate insiders $\mu \leq M$, $\lambda(K = 0) < \lambda(K > 0)$. This implies that $s(K = 0) < s(K > 0)$, $\beta(K = 0) > \beta(K > 0)$, and $B(K = 0) > B(K > 0)$ (where s is the equilibrium bid ask spread given by (3.3.2)). In addition, every trader is worse off (and the market makers face increased risk)*

<u>Proof</u>: The first inequality follows by comparing (5.4) with (2.9). The other three inequalities follow from (3.3.2), (5.2), and (5.3). The traders lose because their trading costs are proportional with λ (see section 4.2) Q.E.D.

If the cost of enforcing L = **B** is borne by the traders, the equilibrium bid ask spread is higher, leading to less informed trading and to a reduction in the expected profit of the traders. This implies that they prefer that the cost of enforcing the law is paid by the current shareholders.

Proposition 5.6: *The welfare of current shareholders increases if the cost of enforcing L = **B** is borne by the traders. Nevertheless, the effort of corporate employees and thereby the gross value of the firm are, for a given supply of corporate insiders, independent of the means of financing the enforcement.*

Proof: If the cost of enforcement is borne by the traders, the net value of the firm increases from $V(\mu) - C(\mu)$ to $V(\mu)$. Finally, e^* and V^* are both independent of how the enforcement cost is financed because the product of λ β is independent of financing (see, e.g., (A9)). Q.E.D.

This suggests that current shareholders prefer the enforcement of the law prohibiting insider trading to be public, and borne by the traders via an additional component in the equilibrium bid ask spread. The traders do not agree so there is a conflict between current and future shareholders.

Optimal enforcement by the regulatory agency

Above the enforcement of $L = B$ is determined to maximize the expected welfare of current shareholders. This is not necessarily the objective if the enforcement is public. The reason is that the regulatory agency has to enforce the security market law according to the instructions given by the authorities (and ultimately by the parliament). As we know, politicians may easily be influenced by various interest groups promoting the interests of their members. Regulation and enforcement may therefore reflect a balance among the heterogeneous interests of diverse groups (see Haddock and Macy (1987)).

This is taken into account by assuming that the regulatory agency maximizes a social welfare function when determining the public enforcement of the law prohibiting insider trading:

$$(5.5)\quad \underset{0\le\mu\le M}{\mathrm{Max}}\, W(\mu) = V(\mu) + \begin{bmatrix} w_1\, \mu\, E\left[\tilde{\pi}_m^{\mu}(\mu) \mid \tilde{y}^* = y^*\right] + w_2\, N\, E\left[\tilde{\pi}_n^{N}(\mu) \mid \tilde{y}^* = y^*\right] + \\ w_3\, Q\, E\left[\tilde{\pi}_q^{Q}(\mu) \mid \tilde{y}^* = y^*\right] + w_4\, (D+1)\, E\left[\tilde{\pi}_d^{D+1}(\mu) \mid \tilde{y}^* = y^*\right] \end{bmatrix} - K(\mu),$$

where $\mathbf{w} = (w_1, w_2, w_3, w_4)$ is a vector of exogenously given welfare weights which determine how much the welfare of one group counts relative to the welfare of another group. The weight of the current shareholders is normalized to one, and the regulatory agency always takes its full cost into account. On the other hand, the welfare weights of the various types of market participants are determined by their political power which again depends on the group's cohesiveness. As suggested by Haddock and Macy (1987), well defined groups such as corporate insiders and, especially, market professionals, might have more influence than rather diffuse groups such as the liquidity traders.

Definition 5.5: An equilibrium enforcement effort by public regulators, denoted μ^{**}, is an enforcement effort such that $W(\mu^{**}) \geq W(\mu')$ for all $\mu' \in [0, M]$.

I am now analyzing μ^{**} for various welfare weights **w**, starting with the case where the groups are equally weighted.

Proposition 5.7: *If $K = k$ and $w = (1, 1, 1, 1)$, then $\mu^{**} = \mu^{*}$.*

Proof: In this case, $W(\mu) = V(\mu) - K(\mu) = V(\mu) - C(\mu)$, and the two functions share therefore the same maximum. The reason is that the securities market is considered to be a zero sum game, and it has therefore no relevance for the social welfare function given by (5.5). Q.E.D.

If the welfare of the security traders does not matter, the optimal enforcement is, as outlined in section 5.4, to maximize the welfare of current shareholders. This, of course, gives the same μ as the solution to condition (4.3).

Some numerical results

It may be realistic to exclude the welfare of the corporate insiders from the social welfare function. After all they are breaking the insider trading law.

Proposition 5.8: *Suppose $K = k$ and $w = (0, 1, 1, 1)$, then there exists a set of parameters where μ^{**} is larger than μ^{*}.*

Proof: I use parameters in table 5.2, and obtain $\mu^{**} = 3.009 > \mu^{*} = 2.777$. However, if N increases from 2 to 12, $\mu^{**} = 1.303 < \mu^{*} = 1.386$. Clearly, μ^{**} is not larger than μ^{*} for every set of parameters. Q.E.D.

It the stock market regulators ignore the welfare of the illegally trading insiders, the number of such traders might be larger than in a corresponding securities market where the stock market regulators maximize the expected welfare of current shareholders. The reason for this is that the insiders who know that they are going to be inside the market, prefer less competition.

The public law enforcement may as mentioned be affected by the political power of various organizations taking care of the interests of their members. If some of the traders have a powerful organization, they may convince the regulators that their welfare should be over-represented in the social welfare function. If, for instance, small traders, trading for reasons other than information, have an organization with much sympathy among politicians and regulators, then w_4 is larger than one.

Proposition 5.9: *Suppose w_4 increases, then μ^{**} tends to increase.*

Proof: I use the parameters in table 5.2, and obtain $\mu^{**} = 3.009$. If w_4 is increased from 1 to 4, μ^{**} increases to 3.780. No example of the opposite is found. Q.E.D.

If liquidity traders prefer L = A and their view is over-represented in the social welfare function, it leads to an enforcement which is less effective than if insider trading was regulated to maximize the expected welfare of current shareholders.

Proposition 5.10: *Suppose M and w_4 are relatively large, then there might exist an equilibrium where $\mu^{**} = M$ and $\mu^* < M$.*

Proof: If M is large, the liquidity traders prefer insider trading allowed or the law prohibiting insider trading not enforced. Since w_4 is large, $\mu^{**} = M$. However, the current shareholders want the law enforced, and they choose to do it themselves. Thus, $\mu^* < M$. I use the parameters given in table 5.2 and find that when $w_4 > 77$, $\mu^{**} = M$ and $\mu^* = 2.777$. Q.E.D.

This suggests that if the public enforcement is very ineffective in the view of current shareholders, they have an incentive to strengthen the enforcement themselves.

5.6 PRODUCTION AND DISCLOSURE OF INFORMATION

In the two previous sections, μ was determined as part of the equilibrium. Yet all the parameters could be determined endogenously in the same way as μ. Here I will restrict myself to determine the quality of inside information and the quality of the signal disclosed to the public where the respective qualities are inversely related to η and γ.

Fishman and Hagerty (1989) analyze a model which is equal to the common information version of corollary 5.4 to determine the optimal quality of information disclosed to a limited number of outsiders (thus, ε and N are determined endogenously). Their main result is that firms may spend more on disclosure than is socially optimal because firms that attract investors by disclosing information have larger market values (see their propositions 2 - 3). It is, of course, possible to obtain similar result in my setting, but I focus instead on disclosure as a tool for "loyal" managers to reduce the need for insider trading as a method of disclosing information to the financial market.

Before the "loyal" managers may disclose information to all the outsiders, they must have produced some internal information to disclose. I assume that production and disclosure are linked together by a linear technology:

$$\gamma = \eta + \nu, \tag{6.1}$$

where $\nu \geq 0$ is noise which is not removed from the public disclosure y^*, but is removed from the internal signal y. If $\nu = 0$, the public disclosure is as precise as inside information. However, y^* does not necessarily equal y because they are diverse signals. If it is cheap to produce information and costly to disclose it to the public, $\nu > 0$.

At time t_3, the problem of the "loyal" managers is to

$$(6.2) \qquad \underset{\substack{0 \le \mu \le M, \\ \eta \ge 0,\ \nu \ge 0}}{\text{Max}} \ V(\mu, \eta, \nu) - C(\mu) - D(\eta, \nu),$$

where $D(\eta, \nu)$ is the cost of producing inside information and disclose some of it to all the outsiders. I assume that

$$(6.3) \qquad D(\eta, \nu) = \frac{c\bullet}{c\bullet\bullet + \eta} + \frac{k\bullet}{k\bullet\bullet + \nu},$$

where $c\bullet, c\bullet\bullet, k\bullet, k\bullet\bullet \ge 0$. This implies that it does not cost anything to produce and disclose noise as $D(\eta \to \infty, \nu \to \infty) = 0$, but disclosing information is costly as $D(\eta < \infty, \nu < \infty) > 0$.

Definition 5.6: *An optimal managerial strategy $\{\mu^*, \eta^*, \gamma^*\}$ of "loyal" managers is a managerial strategy such that $V(\mu^*, \eta^*, \gamma^*) - C(\mu^*) - D(\eta^*, \gamma^*) \ge V(\mu`, \eta`, \gamma`) - C(\mu`) - D(\eta`, \gamma`)$ for all $\mu` \in [0, M]$, $\eta` \in [0, \infty]$, $\gamma` \in [\eta`, \infty]$.*

I concentrate on η^* and γ^* because μ^* is analyzed in sections 5.4 - 5.5. As was the case for μ^*, there is no closed form solution for η^* or γ^*.

Proposition 5.11: *If $c\bullet < c\bullet`$, then $\eta^* = 0$. However, if $c\bullet > c\bullet`$, then $\eta^* > 0$.*

Proof: If $c\bullet = 0$, the cost of producing information is independent of η, and $\eta^* = 0$. This is because $d\, V(\Psi) / d\, \Psi > 0$ and $d\, \Psi / d\, \eta < 0$ which implies that $d\, V(\eta) / d\, \eta < 0$. Let $c\bullet` \ge 0$ be the highest $c\bullet$ where $\eta^* = 0$. If $c\bullet \to \infty$, then $\eta^* \to \infty$ because otherwise the net value of the firm becomes infinitely negative. Let $c\bullet` \le \infty$ be the lowest $c\bullet$ where $\eta^* > 0$. Q.E.D

If it is cheap to produce inside information, the "loyal" managers have an incentive to increase the precision of inside information because it increases the price informativeness either through direct disclosure or insider trading.

Proposition 5.12: *If $k\bullet < k\bullet'$, then $\gamma^* = \eta^*$ (and $\nu^* = 0$). Nevertheless, if $k\bullet > k\bullet'$, then $\gamma^* > \eta^*$ (and $\nu^* > 0$).*

Proof: If $k\bullet = 0$, the cost function is independent of ν, and $\nu^* = 0$. This is because $d\ V(\Psi) / d\ \Psi > 0$ and $d\ V(\nu) / d\ \nu < 0$ which implies that $d\ V(\nu) / d\ \nu < 0$. Let $k\bullet' \geq 0$ be the largest $k\bullet$ where $\nu^* = 0$. If $k\bullet \rightarrow \infty$, then $\nu^* \rightarrow \infty$ because otherwise the net value of the firm is infinitely negative. Let $k\bullet' \leq \infty$ be the lowest $k\bullet$ where $\nu^* > 0$. Q.E.D.

If it is relatively costly to disclose information directly to the public, the "loyal" manager do not disclose as precise information as they possess.

Proposition 5.13: *Suppose the "loyal" managers have regulated the firm to maximize the net value of current shareholders, but the governmental agency instruct the firm to reduce the supply of corporate insiders even further (thus, μ decreases from μ^* to μ^{**}). The new overall optimum means that η tends to decrease from η^* to η^{**} and γ tends to decrease from γ^* to γ^{**}.*

Proof: If μ changes exogenously from μ^* to μ^{**} (holding η^* and γ^* are fixed), the net value of the firm to current shareholders falls from $V(\mu^*, \eta^*, \gamma^*) - C(\mu^*) - D(\eta^*, \gamma^*)$ to $V(\mu^{**}, \eta^*, \gamma^*) - C(\mu^{**}) - D(\eta^*, \gamma^*)$. One way to limit the reduction in the net value of the firm is to change η from η^* to η^{**} and γ from γ^* to γ^{**} so that $V(\mu^{**}, \eta^*, \gamma^*) - C(\mu^{**}) - D(\eta^*, \gamma^*) \leq V(\mu^{**}, \eta^{**}, \gamma^{**}) - C(\mu^{**}) - D(\eta^{**}, \gamma^{**}) < V(\mu^*, \eta^*, \gamma^*) - C(\mu^*) - D(\eta^*, \gamma^*)$. It is optimal to set $\eta^{**} \leq \eta^*$ and $\gamma^{**} \leq \gamma^*$ because of the reduction in the positive informational effect caused by insider trading. The reduction is compensated through a more precise disclosure. This is supported by thorough numerical analyses. Q.E.D.

This suggests that if number of corporate insiders is for some reason or another reduced by the security market regulators (e.g., because insider trading is considered "unfair"), it simultaneously leads to better internal information and to better disclosures to the public. The reason is that the information effect caused by insider trading is reduced, and the managers have to compensate for the loss by improving the direct disclosure which perhaps also means that they have to increase the quality of internal information. Still the reduced supply of corporate insiders reduces the net value of the firm.

My results may suggest that the kind of information which should be prohibited is inside information that would otherwise soon be incorporate into the transaction price through public announcements. This indicates, as suggested in Kyle (1989), that close substitutes for publicly announced data should be banned, but not necessarily trades which are based on private research that compliments public sources of information (see also Manne (1966)). Insider trading may be considered to be a method to disclose the value of business secrets without telling the securities market and thereby the competitors explicitly what they are (see, e.g., Charlton and Fischel (1983)).

5.7 SHORT SUMMARY OF SOME MAJOR CONCLUSIONS

I have developed a simple production and exchange economy, and used it to analyze the supply of productive effort when some the employees are maximizing their own expected welfare and not the expected welfare of their current shareholders. As part of maximizing their own welfare, the agents trade on inside information. I identify three effects on the welfare of current shareholders caused by a law (or contract) prohibiting "disloyal" behavior which includes insider trading:

- If the supply of corporate insiders is reduced, there is a negative information effect which reduces the value of the firms listed on the stock exchange. The reason is that insider trading is a way of disclosing information through the prices which makes them a possible control device for the current shareholders to monitor their agents. This effect is less important if the firms disclose information voluntarily or there are mandatory disclosure requirements.
- If the supply of corporate insiders is reduced, there is a positive production effect which increases the value of the firms listed on the stock exchange. This is because there is a link between being an agent, maximizing his own expected profit, and being a corporate insider. If the employees such as corporate managers cannot trade on inside information, they become "loyal" and therefore maximize the expected welfare of their principals.

- If the supply of corporate insider is reduced, there is a cost effect which may decrease the value of the firms listed on the stock exchange. This effect is caused by the fact that enforcement might be relatively costly.

Given these effects, it is easy within the model to construct examples where insider trading should be prohibited, but not completely enforced as is the situation in many highly developed financial markets such as the NYSE, TSE, and LSE.

A major weakness in this analysis is that there is assumed to be a strong link between agents and corporate insiders. If the number of corporate insiders is reduced in the financial market by outlawing such trades, the number of agents is also reduced. This is not necessarily the case, corporate employees may be prevented from trading on inside information, but may still act as "disloyal" agent within the firm by shrinking their duties vis-à-vis their principals.

I extend in the next chapter to a corresponding production and exchange economy where the unfaithful insiders in some respects are even more unfaithful as they supply an effort different from the effort expected by the market. This implies that the corporate insiders have privileged information generated by their own choice of effort. In this way, the corporate insiders are actually manipulating the production process to obtain inside information.

APPENDICES

This section contains the formal proofs of lemma 5.2 and 5.4. Appendix C gives the numerical values used in the example.

Appendix A Proof of lemma 5.2

The "loyal" and the "disloyal" managers have two different effort-selection problems given by (3.3) or (3.4) and (3.5) respectively.

If the "loyal" managers are far-sighted, their effort-selection problem is given by (3.4). I insert the cost function given by (3.2) and obtain the first order condition

(A1) $$1 - c\,e_m = 0,$$

or

(A2) $$e_m^{**} = \frac{1}{c}.$$

The second order condition is $- c < 0$, and I conclude that this choice of effort produces a maximum. If $\Psi \to \infty$, (3.6) equals (A2).

If instead the corporate managers are myopic or shortsighted, their effort-selection problem is given by (3.3). I insert the transaction price given by (2.7) and the cost function given by (3.2), and yield

(A3) $$\underset{e_m \geq 0}{\mathrm{Max}}\ \frac{1}{R}\left\{E\left[E[\tilde{x} + e \mid \tilde{y}^*] \mid e_m\right] + \lambda\, E\left[E[\tilde{z} \mid \tilde{y}^*] \mid e_m\right] - \frac{c}{2} e_m^2\right\},$$

where the net order flow

(A4) $$\tilde{z} = \beta \sum_{n=1}^{N}\left(\tilde{y}_n - E[\tilde{x} + e \mid \tilde{y}^*]\right) + \mu B\left(\tilde{y} - E[\tilde{x} + e \mid \tilde{y}^*]\right) + \tilde{u}.$$

At time t_4, y^* is not realized and it is therefore a stochastic variable. But the manager knows that y^* will be realized at time t_3 and takes it into account. The future revelation of superior information is taken into account through the adjustment caused by the net order flow. The next step is to use the rule of conditional expectations and obtain

(A5) $$\underset{e_m \geq 0}{\mathrm{Max}}\frac{1}{R}\left\{E\left[E[\tilde{x} + e] + \frac{\mathrm{cov}(\tilde{x} + e,\, y^*)}{\mathrm{var}(\tilde{y}^*)}\begin{pmatrix}\tilde{y}^* - \\ E[\tilde{y}^*]\end{pmatrix} \mid e_m\right] + \lambda\, E\left[E[\tilde{z}] + \frac{\mathrm{cov}(\tilde{z},\, y^*)}{\mathrm{var}(\tilde{y}^*)}\begin{pmatrix}\tilde{y}^* - \\ E[\tilde{y}^*]\end{pmatrix} \mid e_m\right] - \frac{c}{2} e_m^2\right\},$$

in which

(A6) $$\mathrm{cov}(\tilde{y}^*, \tilde{z}) =$$

$$\mathrm{cov}\left(\tilde{x} + e + \tilde{g},\ \frac{(N\beta + \mu B)\gamma}{\delta + \gamma}(\tilde{x} + e) + \beta\sum_{n=1}^{N}\tilde{e}_n + \mu B\tilde{h} + \tilde{u} - \frac{N\beta + \mu B}{\delta + \gamma}\left[\gamma\left(m_x + e^c\right) + \delta\tilde{g}\right]\right) = 0,$$

where e^c is the market's conjecture about total effort. We observe that the market orders from the informed speculators and the liquidity traders are not driven by public information. This means that (A5) simplifies to

$$\text{(A7)} \quad \underset{e_m \geq 0}{\mathrm{Max}}\ \frac{1}{R}\left\{\begin{array}{c} m_x + e^c + \dfrac{\delta}{\delta + \gamma}\left(e_m - e^c_m\right) + \\ \lambda E\left[\left[N\beta\left(\tilde{y}_n - E[\tilde{x} + e \mid \tilde{y}^*]\right) + \mu B\left(\tilde{y} - E[\tilde{x} + e \mid \tilde{y}^*]\right) + \tilde{u} \mid e_m\right] \mid e_m\right] - \dfrac{c}{2}e_m^2 \end{array}\right\},$$

where e^c_m is the market's conjecture about the effort supplied by manager m. After taking the expectation, I get

$$\text{(A8)} \quad \underset{e_m \geq 0}{\mathrm{Max}}\ \frac{1}{R}\left\{\begin{array}{c} m_x + e^c + \dfrac{\delta}{\delta + \gamma}\left(e_m - e^c_m\right) + \\ \lambda\left\{N\beta\left(e_m - e^c_m - \dfrac{\delta}{\delta + \gamma}(e_m - e^c_m)\right) + \mu B\left(e_m - e^c_m - \dfrac{\delta}{\delta + \gamma}\left(e_m - e^c_m\right)\right)\right\} - \dfrac{c}{2}e_m^2 \end{array}\right\},$$

or

$$\text{(A9)} \quad \underset{e_m \geq 0}{\mathrm{Max}}\ \frac{1}{R}\left\{m_x + \sum_{m=1}^{M-1} e^c_m + \frac{\left[1 - \lambda\beta(N + \mu\alpha)\right]\gamma}{\delta + \gamma}e^c_m + \frac{\delta + \lambda\beta(N + \mu\alpha)\gamma}{\delta + \gamma}e_m - \frac{c}{2}e_m^2\right\}.$$

According to (3.C1), the informativeness of the transaction price (which is measured by $\Psi = 1 / \mathrm{var}(x \mid S, y^*=y^*)$) equals

$$\text{(A10)} \qquad \Psi = \frac{1}{\Gamma\left[1 - \lambda\beta(N + \mu\alpha)\right]} = \frac{\delta + \gamma}{\delta\gamma\left[1 - \lambda\beta(N + \mu\alpha)\right]}.$$

The next step is to insert (2.4) and (2.9) into (A10). The result is given by (3.7). Finally, I substitute (A10) into (A9), and obtain

(A11) $$\underset{e_m \geq 0}{\text{Max}} \; \frac{1}{R}\left\{ m_x + \sum_{m=1}^{M-1} e^c_m + \frac{e^c_m}{\delta \Psi} + \left[1 - \frac{1}{\delta \Psi}\right] e_m - \frac{c}{2} e^2_m \right\}.$$

The first order condition is ($e^c{}_m$ and $\Sigma e^c{}_m$ are taken to be constants, suggesting that the manager has Nash-conjectures)

(A12) $$\left[1 - \frac{1}{\delta \Psi}\right] - c\, e_m = 0.$$

where Ψ is given by (3.7). The optimal choice of individual effort given by (3.6) follows directly. The second order condition is $- c < 0$, and I may conclude that the manager's choice of individual effort produces a maximum.

The "disloyal" manager $m \in \{1, 2, ..., \mu\}$ chooses an individual effort e_m which maximizes the effort-selection problem given by (3.5). I insert the cost function given by (3.2) and yield

(A13) $$\underset{e_m \geq 0}{\text{Max}} \; \frac{1}{R}\left\{ E\left[\tilde{\pi}^\mu_m \mid e_m\right] + \frac{c}{2}\left(e^*_m\right)^2 - \frac{1}{2}\left[c\, e^2_m + c\left(e_m - e^*_m\right)^2\right] \right\},$$

where $e^*{}_m$ is a constant given by (3.6). In this chapter, I assume that the managers cannot trade on effort generated information which means that $E[\pi_m{}^\mu \mid e_m]$ is a constant independent of e_m. This implies that the "disloyal" manager has a constant revenue, and the problem is to minimize the cost function. The first order condition is

(A14) $$- \left[c\, e_m + c\left(e_m - e^*_m\right)\right] = 0.$$

The optimal choice of effort is given by (3.8). The second order condition is $- (c + c) < 0$ which means that I have found a maximum.

The total effort is

(A15) $$e^* = (M - \mu)\, e^*_m + \mu\, e^\bullet_m.$$

I insert (3.6) and (3.8) and yield (3.9).

The expected value of the firm at time t_4 as a function of the "loyal" managers' supply of individual effort is

$$\text{(A16)} \qquad V(e_m) = \frac{1}{R}\left\{m_x + (M - \mu)\, e_m + \mu \frac{c}{c + c} e_m - M \frac{c}{2} e_m^2\right\},$$

where I have inserted (3.8). Notice that the principals pay all the managers for supplying the effort of a "loyal" managers because the principals cannot distinguish "loyal" from "disloyal" managers. I insert (3.6) and yield (3.10). This completes the proof of lemma 5.2.

Appendix B Proof of lemma 5.4

I want the market makers to earn a positive expected profit which equals the cost of enforcing the law prohibiting insider trading. This means that the equilibrium condition in the dealership market with competitive market makers is

$$\text{(B1)} \qquad E\left[- \tilde{z}\left(\tilde{x} - R\,\tilde{S}\right) \mid \tilde{z},\, \tilde{y}^* = y^*\right] = K(\mu),$$

giving the linear price function given by (2.8). The price sensitivity is

$$\text{(B2)} \qquad \lambda = \frac{\operatorname{cov}(\tilde{x}, \tilde{z} \mid \tilde{y}^* = y^*)}{\operatorname{var}(\tilde{z} \mid \tilde{y}^* = y^*)} + \frac{K(\mu)}{\tilde{z}^2}.$$

In this way, the price sensitivity depends of the size of the order flow. Such quotation is called order driven because it depends on the observed orders. Thus, the equilibrium bid ask spread is adjusted after the intermediaries have received the orders.

I want λ to be independent of z. One way of doing this is to assume that the transaction price is linear in the net order flow and the price setting market makers have to quote the price sensitivity before they observe the net order flow. This means that the intermediaries have to hold on to the quoted spread after they actually observe the realization of net order flow. Such a way of determining the bid ask spread is called quotation driven.

$$\text{(B3)}\quad E[\lambda \mid \tilde{y}^* = y^*] = E\left[\frac{\operatorname{cov}(\tilde{x}, \tilde{z} \mid \tilde{y}^* = y^*)}{\operatorname{var}(\tilde{z} \mid \tilde{y}^* = y^*)} + \frac{K(\mu)}{\tilde{z}^2} \mid \tilde{y}^* = y^*\right] = \frac{\operatorname{cov}(\tilde{x}, \tilde{z} \mid \tilde{y}^* = y^*) + K(\mu)}{\operatorname{var}(\tilde{z} \mid \tilde{y}^* = y^*)}.$$

The price setting market makers do not earn a profit to cover $K(\mu)$ for all realizations of z, but only on average, implying that they earn more than $K(\mu)$ if $z^2 > \operatorname{var}(z \mid y^*=y^*)$ and lose if the opposite is the case. I insert (5.1) and (A4) and yield

$$\text{(B4)}\qquad \lambda = \frac{\beta(N + \mu\alpha) + K(M - \mu)^2}{\beta^2\left[(N + \mu\alpha)^2 \Gamma + N\varepsilon + \mu^2\alpha^2\eta\right] + \sigma},$$

where β is given by (2.A30) and restated in (5.3). I insert (5.3) and obtain

$$\text{(B5)}\qquad \sigma\lambda^2 - K(M - \mu)^2 \lambda - \frac{\left[N(\Gamma + \varepsilon) + \mu(\Gamma + \eta)\alpha^2\right]\Gamma^2}{\left[N\Gamma + (\mu + 1)(\Gamma + \eta)\alpha\right]^2} = 0.$$

This equation has one positive root given by (5.4). Equation (5.2) follows from (2.3.4). This completes the proof of lemma 5.4.

Appendix C Example

Table 5.2 gives the numerical values used to illustrate the optimal choice of μ.

TABLE 5.2:				Numerical values				
δ	=	2	[σ	=	1]	N	=	2
γ	=	2	c	=	1	M	=	10
ε	=	2	c	=	1	μ	$\in$	{1, 2, ..., M}
η	=	1	k	=	1/20	R	=	1
						m_x	=	0

Notice that the "disloyal" managers are expected to produce only half of what the "loyal" managers are expected to produce (because c / (c + c) = 1/2).

REFERENCES

Admati, A., and P. Pfleiderer, 1989, "Divide and Conquer: A Theory of Intraday and Day-of-the-Week Mean Effects," Review of Financial Studies, 189 - 223.

Bhattacharya, S., 1989, "Financial Markets and Incomplete Information: A Review of Some Recent Developments," Chapter 1 in S. Bhattacharya and G. M. Constantinides, "Financial Markets and Incomplete Information. Frontiers of Modern Financial Theory," Volume 2, Rowman and Littlefield, 1 - 19.

Charlton, D. W., and D. R. Fischel, 1983, "The Regulation of Insider Trading," Stanford Law Review, 857 - 895.

Diamond, D. W., 1985, "Optimal Release of Information by Firms," Journal of Finance, 1071 - 1094.

Fishman, M. J., and K. M. Hagerty, 1989, "Disclosure Decisions by Firms and the Competition for Price Efficiency," Journal of Finance, 633 - 646.

Haddock, D. D., and J. R. Macey, 1987, "Regulation on Demand: A Private Interest Model, with and Application to Insider Trading Regulation," Journal of Law and Economics, 311 - 352.

Holmström, B., 1979, "Moral Hazard and Observability," Bell Journal of Economics, 74 - 91.

Kyle, A. S., 1989, "Imperfect competition, Market Dynamics, and Regulatory Issues," Discussion in S. Bhattacharya and G. M. Constantinides, "Financial Markets and Incomplete Information. Frontiers of Modern Financial Theory," Volume 2, Rowman and Littlefield, 153 - 161.

Manne, H. G., 1966, "Insider Trading and the Stock Market," Free-Press.

Ross, S., 1979, "Disclosure Regulation in Financial Markets: Implications of Modern Finance Theory and Signalling Theory," Chapter 4 in F. Edwards (ed.), "Issues in Financial Regulation," McGraw-Hill, 177 - 216.

Stoll, H. R., 1985, "Alternative Views of Market Making," Chapter 4 in Y. Amihud, T. Ho, and R. Schwartz, "Market Making and the Changing Structure of the Securities Industries," Lexington.

CHAPTER 6

INSIDER TRADING ON EFFORT GENERATED INFORMATION

First draft: April 1991,

Current revision: November 1992.

ABSTRACT

I examine insider trading as a mechanism promoting managerial effort. My findings show that trading on effort generated information promotes an equilibrium supply of effort that is either incentive compatible or destructive. This is because corporate managers of higher than average quality are motivated to supply an effort higher than expected, and, symmetrically, the managers of lower than average quality find it easier to surprise the market by supplying an effort less than expected. In this way, effort is random which generates superior information unavailable to outsiders. I compare the expected effort and its volatility when insider trading is the sole incentive mechanism with a corresponding market where insider trading is prohibited. The managers are instead motivated by a linear outcome-contingent incentive scheme. My results indicate that insider trading is not desirable as an incentive mechanism because the linear outcome-contingent scheme produces a higher expected effort and reduces the volatility of the effort choices.

6.1 INTRODUCTION

This chapter extends the pure exchange economy characterized by lemma 2.1 to a corresponding production and exchange economy where the corporate employees maximize their own expected profit. They do this by supplying an effort different from what is expected by their principals and by the securities market in general. Hence, the employees are considered to be agents who choose the individual effort which maximizes their own expected profit and not necessarily the one that maximizes the expected profit of their principals. By choosing an unexpected effort, the employees generate inside information exploitable by trading in the securities market. This in turn may suggest that there is a close link between information gathering and production in general. Clearly, this incentive effect has to be taken into consideration when evaluating the desirability of insider trading regulations in financial markets.

The major problem in the agency model is that the principals do not directly infer the action of their agents by observing the outcome of the production process. A partial solution is to implement an outcome-contingent incentive scheme which motivates the agents to supply an effort consistent with the interest of their principals; see, e.g., Holmström (1979) for a theoretical discussion. The question raised here is whether insider trading *per se* is such a mechanism or, as implicitly suggested in chapters 2 - 4, merely trade on superior information. If it turns out that insider trading really has incentive effects, then, as originally pointed out by Manne (1966), it may be desirable to allow such trades at least if no other mechanisms provide the desired effort at significantly lower costs.

There are few who have analyzed this question formally. One is Dye (1984) who analyzes incentives and insider trading in an agency model extended with a simple security market where one manager may trade on internal information. His findings indicate that if the manager is initially compensated through an earning-contingent contract, the welfare of that risk averse insider and all of the risk averse shareholders can be improved by insider trading (see also Easterbrook (1985)). Note, however, that this does not generally establish the superiority of schemes that have, as one component of compensation, profits from insider trading. Rather, it establishes that insider trading is one mechanism that may be used by the shareholders to improve on earnings-contingent contracts either because of incentive effects or its risk sharing properties.

Another area of literature relevant when discussing these issues is the articles and papers analyzing various other effects caused by insider trading. Often these articles use extended exchange economies where investments or production are allowed (see, e.g., Manove (1989), Ausubel (1990), Dennert (1990), Fishman and Hagerty (1992), and Leland (1992)). Leland, for instance, studies insider trading in a security market model which recognizes the monopoly power of a single corporate insider, and finds that the expected production is larger with insider trading than without. He concludes that if the amount of investment is highly responsive to current stock prices, the total welfare tends to increase with insider trading. However, the insider does not supply any productive effort. Instead production happens because the supply of the firm's stock is decided by "the firm", possessing no inside information, to maximize expected profit for its original shareholders. Production means that the original stockholders earn more money by selling more shares to satisfy the demand. Leland's insider does not even decide the supply of the stock, so there are no function initially justifying his existence. The other papers are affected by the same critique because they do not recognize the corporate insiders as agents, supplying effort to maximize their own welfare.

I extend the framework used in the earlier chapters to a principal - agent setting with the following sequence of events. First, the principals hire several risk neutral employees who have a non-observable ability to make effort. Then the hired employees maximize their own expected profit by individually choosing such an action. Their effort is not directly observed by the principals or any other outsiders because random business fluctuations outside the control of the employees are affecting the output and thereby making it noisy. Finally, the corporate employees become insiders in the securities market, and trade on effort generated information to compensate for their supply of effort. Insider trading is allowed because their trades are part of the remuneration contract with their principals. All agents are risk neutral excluding risk sharing considerations from the analysis.

There are two types of equilibrium choices of effort. An incentive compatible choice is one in which the corporate employees choose to supply an effort greater than expected, and, correspondingly, a destructive choice is one in which the employees choose to supply an effort lower than expected by the market. The employees, of course, know their own ability, and always choose the supply of effort which gives them the highest expected profit. In equilibrium, the employees with lower abilities than average tend to be destructive whereas the employees with higher abilities tend to surprise the market positively. The amount of effort generated information increases with the uncertainty about the quality of the firm`s employees, and decreases with the cost of surprising the market. Surprising the market is costly, among other things, because it hurts the long run reputation of the managers (see, e.g., Holmström (1982)). Nevertheless, if it becomes more costly to surprise the market, the corporate employees have less inside information which in turn is shown to benefit outsiders such as market professionals and liquidity traders.

Insider trading as an incentive mechanism gives some of the corporate employees an incentive to supply a low effort to generate superior information. This suggests that insider trading is not very effective as an incentive mechanism, and it is confirmed if we compare insider trading with linear outcome-contingent incentive schemes. I find that a large sub-class of linear outcome-contingent incentive schemes dominates insider trading because insider trading leads to less expected effort and increases its volatility. My results run counter to the one obtained by Manne (1966). He claims that the perfect remuneration device for entrepreneurs is to allow them to trade on information generated by their entrepreneurial activity. The conclusion is that insider trading is not effective as an incentive mechanism (but may have positive risk sharing effects as shown by Dye (1984)).

The remainder of this chapter is organized as follows. The next section discusses the assumptions, and section three presents the resulting trading equilibrium. This equilibrium extends lemmas 2.1 - 2.2 to a common more general equilibrium. Optimal effort with insider trading as the sole incentive scheme is the topic of section four, and the overall equilibrium in the resulting production and exchange economy is presented in lemmas 6.4 - 6.5. Section five discusses the properties of the equilibrium, focusing on the employees` choice of effort, and section six analyzes, e.g., what happens to the welfare of all participants if the corporate employees surprise the market by choosing an unexpected effort. Sections seven concentrates on a question related to the employees` choice of effort, namely their choice of business risk with insider trading as an incentive mechanism. In section eight, insider trading is compared with other alternative incentive mechanisms in order to analyze whether insider trading is the most effective way to motivate employees to supply a productive effort. Section nine concentrates on whether the current shareholders are able to confiscate the abnormal returns earned by the corporate managers and other employees by punishing them if the future value of the firm differs from the expected value. Finally, section ten summarizes the major conclusions. Some formal proofs are found in the appendices.

6.2 ASSUMPTIONS

I draw on the stock market economy outlined in section 2.2, and extend it to a corresponding economy where (i) the corporate insiders are employees who consequently have to make a costly individual effort which is not directly observed by the outsiders, and (ii), if they choose to supply an unexpected effort, the corporate insiders are able to trade on a new source of information which is not correlated with the random business fluctuations traded on in earlier chapters.

I start by assuming that the future value of firm $k \in \{1, 2, ..., K\}$ is a random variable with two components

$$\tilde{x} + \tilde{e}. \tag{2.1}$$

The first term is the net effect caused by random business fluctuations whereas the second term is the net effect caused by security-specific events on the value of firm k. Examples of security-specific events are the productive effort and the investment decisions provided by the corporate employees. This implies that e may depend on the number of employees. How the corporate managers determine their supply of effort is analyzed separately in sections 6.4 - 6.5, using the trading equilibrium given by lemma 6.1. Until then, the effort component in the future value of the security is given exogenously. I assume that

$$\tilde{x} \sim N(m_x, \delta), \tilde{e} \sim N(m_e, \phi), \text{ and} \\ \operatorname{cov}(\tilde{x}, \tilde{e}) = 0. \tag{2.2}$$

where $N(\cdot, \cdot)$ implies that the random variable is normally distributed with a publicly known mean and variance. As we see, the two components in (2.1) are not correlated.

There are two signals disclosed to the public just before trading at time $t \in \{0, 1, ..., T_k - 1\}$; see figure 6.1. One of the signals is correlated with the random business fluctuations; the other is correlated with the total effort of corporate employees. In this way,

$$(2.3) \qquad \tilde{y}^* = \tilde{x} + \tilde{g} \text{ and } \tilde{y}_\bullet = \tilde{e} + \tilde{j}.$$

I assume that

$$(2.4) \qquad \tilde{g} \sim N(0, \gamma), \tilde{j} \sim N(0, \varphi), \text{ and}$$
$$\operatorname{cov}\left(\tilde{g}, \tilde{j}\right) = \operatorname{cov}\left(\tilde{g} + \tilde{j}, \tilde{x} + \tilde{e}\right) = 0.$$

The public information is used to update the expectations and variances of the two components in the future value of the security. This means that

$$(2.5) \qquad \tilde{x} \sim N\left(E[\tilde{x} \mid \tilde{y}^* = y^*], \Gamma = \frac{\delta \gamma}{\delta + \gamma}\right) \text{and } \tilde{e} \sim N\left(E[\tilde{e} \mid \tilde{y}_\bullet = y_\bullet], \Phi = \frac{\phi \varphi}{\phi + \varphi}\right),$$

in which $\lim_{\gamma \to \infty} E[x \mid y^*=y^*] = m_x$, $\lim_{\varphi \to \infty} E[e \mid y_\bullet=y_\bullet] = m_e$, $\lim_{\gamma \to \infty} \Gamma = \delta$, and $\lim_{\varphi \to \infty} \Phi = \phi$. In this way, disclosing information to the public reduces the underlying uncertainty about the future value of the security.

In addition to the public signals y^* and $y_\bullet$, there are three private signals which are observed only by a limited number of individuals. The corporate insiders share one signal correlated with the random fluctuations and one signal correlated with the total internal effort:

$$(2.6) \qquad \tilde{y} = \tilde{x} + \tilde{h} \text{ and } \tilde{Y} = \tilde{e} + \tilde{i},$$

where

$$(2.7) \qquad \tilde{h} \sim N(0, \eta), \tilde{i} \sim N(0, \iota), \text{ and}$$
$$\operatorname{cov}\left(\tilde{h}, \tilde{i}\right) = \operatorname{cov}\left(\tilde{h} + \tilde{i}, \tilde{x} + \tilde{e}\right) = \operatorname{cov}\left(\tilde{h} + \tilde{i}, \tilde{g} + \tilde{j}\right) = 0.$$

Each of the market professional observe one signal each correlated with the random business fluctuations influencing the future value of the security.

$$\tilde{y}_n = \tilde{x} + \tilde{e}_n, \tag{2.8}$$

where (e_n is noise and has nothing to do with effort)

$$\tilde{e}_n \sim N(0, \varepsilon) \text{ and} \tag{2.9}$$
$$\mathrm{cov}\left(\tilde{e}_n, \tilde{h} + \tilde{i}\right) = \mathrm{cov}\left(\tilde{e}_n, \tilde{x} + \tilde{e}\right) = \mathrm{cov}\left(\tilde{e}_n, \tilde{g} + \tilde{j}\right) = 0.$$

Note that y_n is a diverse signal (each observer observes his own realization) whereas y and Y are both common signals (all observers share one signal). The signals observed by superiorly informed speculators are both correlated and uncorrelated because

$$\mathrm{cov}\left(\tilde{y}, \tilde{Y} \mid I\right) = \mathrm{cov}\left(\tilde{Y}, \tilde{y}_n \mid I\right) = 0 \text{ and } \mathrm{cov}\left(\tilde{y}, \tilde{y}_n \mid I\right) = \Gamma, \tag{2.10}$$

where $I = \{y^*=y^*, y^\bullet=y^\bullet, ...\}$ is an information structure which presents public information which includes the realizations of the public signals, but not the future realization of the transaction price. See section 2.2 for further comments on these issues.

Both corporate insiders and market professionals have an incentive to trade on non-public information at the call auction at time $t \in \{0, 1, ..., T_k - 1\}$. This is because superior information generates expected profit. I assume that the corporate insiders are risk neutral which means that the portfolio-selection problem of insider m $\in \{1, 2, ..., M\}$ is

$$\underset{\Delta_m}{\mathrm{Max}}\ E\left[\tilde{\Delta}_m \left((\tilde{x} + \tilde{e}) - R\,\tilde{S}\right) \mid \tilde{I}_m, I\right], \tag{2.11}$$

where S is the transaction price and $I_m = \{y, Y\}$ represents inside information available to the corporate insiders. The corporate insider is not compensated in any other way than through insider trading, but insider trading is compared with an alternative incentive mechanism in section 6.8. The solution of (2.11), denoted $\Delta_m(y, Y)$ is the market order coming from corporate insider m, and it is at time t_1 submitted, together with orders from other traders, to the price setting market makers. The market professionals are risk neutral which means that the portfolio-selection problem of professional $n \in \{1, 2, ..., N\}$ is

$$\text{(2.12)} \qquad \max_{\tilde{\theta}_n} E\left[\tilde{\theta}_n\left((\tilde{x} + \tilde{e}) - R\,\tilde{S}\right) \mid \tilde{y}_n, I\right],$$

where y_n represents the privately acquired signal. The solution of (2.12), denoted $\theta_n(y_n)$, is the market order coming from professional n, and it is at time t_{-1} submitted, together with orders from other traders, to the market makers.

There are in addition to the informed speculators three types of uninformed individuals. The first type is the stable owners who are risk neutral and own a fraction $(1 - v) \in [0, 1]$ of the firm. They are assumed to hold their initial position in the period from t to t+1. The second type is w (D + 1) uninformed liquidity traders where $w \in [0, 1]$. They are risk neutral and own a fraction v of the firm, and differ from the stable owners because they, in addition to hold stocks, choose to trade in the period for exogenous reasons. The third type of uninformed traders are (1 - w) (D + 1) pure liquidity traders who do not own any initial position in the firm, but take long or short positions according to their liquidity needs. The net demand from the liquidity traders is

$$\text{(2.13)} \qquad \tilde{u} = \sum_{d=0}^{D} \tilde{u}_d \sim N\left(0,\ \sigma = \sum_{d=0}^{D} \sigma_d\right).$$

In this way, the liquidity traders create noise so the market professionals and the corporate insiders are camouflaged in the net order flow.

The transaction price is determined by risk neutral dealers or market makers. They are supposed to act competitively which means that market maker $q \in \{1, 2, ..., Q\}$ has to quote a bid ask spread and thereby a market price according to the equilibrium condition in the dealership market.

$$\text{(2.14)} \qquad E\left[-\left(\frac{\tilde{z}}{Q}\right)\left((\tilde{x} + \tilde{e}) - R\,\tilde{S}\right) \mid \tilde{z}, I\right] = 0,$$

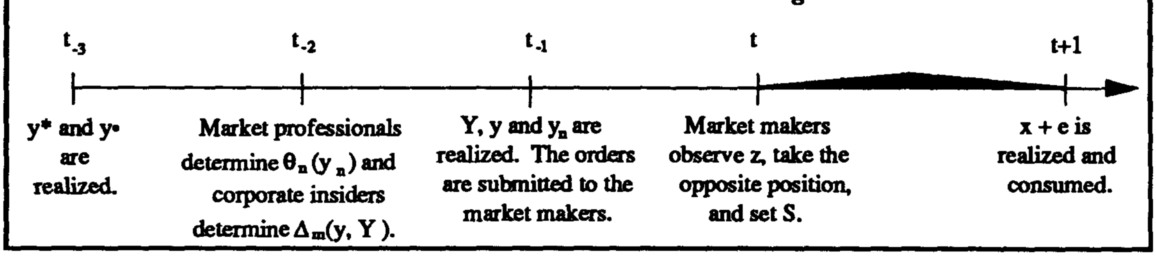
where z is the net order flow from the informed speculators and the uninformed liquidity traders, S is the transaction price determined by the market makers, and conditioned z is the information generated by observing the net flow of orders.

The next table summarizes the share positions and the cash distributions to all the individuals present in the economy.

TABLE 6.1:	Share position	Cash distributions
Stable owners	$1 - v$	$(1 - v)(\tilde{x} + \tilde{e})$
Liquidity trading owners	$v + w\tilde{u}$	$v(\tilde{x} + \tilde{e}) + w\tilde{u}\left((\tilde{x} + \tilde{e}) - R\tilde{S}\right)$
Pure liquidity traders	$(1 - w)\tilde{u}$	$(1 - w)\tilde{u}\left((\tilde{x} + \tilde{e}) - R\tilde{S}\right)$
Market professionals	$\sum_{n=1}^{N}\tilde{\theta}_n$	$\sum_{n=1}^{N}\tilde{\theta}_n\left((\tilde{x} + \tilde{e}) - R\tilde{S}\right)$
Corporate insiders	$\sum_{m=1}^{M}\tilde{\Delta}_m$	$\sum_{m=1}^{M}\tilde{\Delta}_m\left((\tilde{x} + \tilde{e}) - R\tilde{S}\right)$
Market makers	$-\sum_{q=1}^{Q}\tilde{z}_q$	$-\sum_{q=1}^{Q}\tilde{z}_q\left((\tilde{x} + \tilde{e}) - R\tilde{S}\right)$
Total	1	$\tilde{x} + \tilde{e}$

The sum of share positions is normalized to unity which means that the supply of shares is non-flexible.[1] Figure 6.1 gives the sequence of events around time t where the shares of firm k are traded (t_{-1} means just before time t, t_{-2} means just before time t_{-1}, and so on).

FIGURE 6.1 The time structure of trading



[1] In Leland (1992) production means that the supply of shares is flexible and determined to maximize the welfare of the initial owners of the firm. This extension is also possible in this model, but in section 6.4 a different approach is chosen.

Note that the informed speculators form their demand at time t_{-2} before they at time t_{-1} actually observe the realizations of their signals Y, y and y_n. This means that their demands are functions of the forthcoming signals. On the contrary, they have at that time already incorporated the realized public signals y* and y• into their demand functions. Thus, at time t_{-2} some stochastic variables are realized, others are going to be realized in the near future.

6.3 TRADING EQUILIBRIUM

This section gives the trading equilibrium in the outlined economy and thereby extending both lemma 2.1 and 2.2 to a common generalized equilibrium. This equilibrium is used in sections 6.5 - 6.9 to analyze the effects of insider trading on production.

Lemma 6.1: *There exists a unique, linear trading equilibrium* $[(\theta_{nkt}, \Delta_{mkt}, u_{kt}), S_{kt};\ n \in \{1, 2, ..., N\},\ m \in \{1, 2, ..., M\},\ k \in \{1, 2, ..., K\},\ t \in \{0, 1, ..., T_k - 1\}]$ *for security k at auction t. The trading strategies of the market professionals and the corporate insiders are*

(3.1)
$$\tilde{\theta}_n = \beta\left(\tilde{y}_n - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \textit{ and}$$

(3.2)
$$\tilde{\Delta}_m = b\left(\tilde{Y} - E[\tilde{e} \mid \tilde{y}_\bullet = y_\bullet]\right) + B\left(\tilde{y} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right),$$

where the trading intensities are

(3.3)
$$\beta = \sqrt{\frac{\sigma}{N(\Gamma + \varepsilon) + M\{(\Gamma + \eta)\alpha^2 + (\Phi + \iota)a^2\}}},$$

(3.4)
$$b = a\beta, \textit{ and}$$

(3.5)
$$B = \alpha\beta,$$

in which

$$(3.6)\qquad \mathbf{a} = \frac{\left(N\Gamma + (M+1)(\Gamma+\eta)\,\alpha\right)\Phi}{(M+1)(\Phi+\iota)\,\Gamma}, \text{ and}$$

$$(3.7)\qquad \alpha = \frac{\Gamma + 2\,\varepsilon}{\Gamma + (M+1)\,\eta}.$$

The transaction price is

$$(3.8)\qquad \tilde{S} = \frac{1}{R}\left\{E[\tilde{x} + \tilde{e} \mid \tilde{y}^* = y^*, \tilde{y}_\bullet = y_\bullet] + \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m + \tilde{u}\right)\right\},$$

where the price sensitivity

$$(3.9)\qquad \lambda = \frac{\Phi}{(M+1)(\Phi+\iota)\,\mathbf{a}}\sqrt{\frac{N(\Gamma+\varepsilon) + M\left\{(\Gamma+\eta)\,\alpha^2 + (\Phi+\iota)\,\mathbf{a}^2\right\}}{\sigma}}.$$

If $L = \boldsymbol{B}$, then μ replaces M.

Proof: See appendix A.

If the total effort supplied by the corporate employees in firm k from time t to t+1 depends on their number, also its expectation and variance will depend on the number of employees. In this way, $\Phi = \Phi(M, ...)$ would be determined as part of the equilibrium; see section 6.4 for further elaborations. These corollaries follow immediately.

Corollary 6.1: *Suppose the corporate insiders and the market professionals observe only correlated information, then the trading equilibrium is given by lemma 2.1.*

Proof: If $\iota \to \infty$, then $a = 0$, $b = 0$, and β, B, and λ have the values given by (2.3.3), (2.3.4), and (2.3.8) respectively. Q.E.D.

Corollary 6.2: *Suppose the corporate insiders and market professionals observe only uncorrelated information, then the trading equilibrium is given by lemma 2.2.*

Proof: If $\eta \to \infty$, then $\alpha = 0$, $B = 0$, and β, b, and λ have the values given by (2.6.10), (2.6.11), and (2.6.15) where a is given by (2.6.12). Q.E.D

Lemma 6.1 could easily be extended to numerous of market architectures. For instance, to the case where there are two types of corporate insiders, one observing information correlated with the random business fluctuations and another observing information correlated with the firm-specific component in the future return of the security. Notice that this situation equals the one in lemma 6.1 if the numbers of the two types of insiders are identical.

6.4 OPTIMAL EFFORT

I have assumed that the information represented by signal Y is correlated with the term e in the future value of security $k \in \{1, 2, ..., K\}$; see (2.6). If e is the value of the total effort supplied by the corporate employees, Y is said to be generated by total effort. I did not in the previous sections specify how information is generated from effort. This is the topic of this section.

At time t_4, corporate manager $m \in \{1, 2, ..., M\}$ determines his optimal action e_m which could in general include effort choices, investment and production decisions, project selections etc., but the managers' choice of action does not affect the random business fluctuations or vice versa. The optimal action is determined to maximize expected profit. Thus, if $L = A$, e_m is determined by

$$(4.1) \qquad \underset{\tilde{e}_m}{\text{Max}}\ E\Big[\tilde{\Delta}_m(\tilde{e}_m)\Big[\big(\tilde{x} + \tilde{e}(\tilde{e}_m)\big) - R\,\tilde{S}(\tilde{e}_m)\Big] - \tilde{C}(\tilde{e}_m) \mid \tilde{e}_m, \tilde{c}, \tilde{I}\Big],$$

where $C(e_m)$ is a stochastic cost depending on the individual choice of action or effort. The conditional c and e_m represent superior information about the manager's own cost structure (that is, the manager's type or quality) and his own supply of effort.

Definition: *The optimal individual action or effort e^*_m is an effort such that $E[\pi_m(e^*_m) \mid e_m, c, I] \geq E[\pi_m(e'_m) \mid e_m, c, I]$ for all e'_m where π_m is the profit of manager $m \in \{1, 2, ..., M\}$.*

The total effort is the sum of the individual efforts (that is, $e = \Sigma\, e_m$) where the optimal individual effort e^*_m is characterized by the next result.

Lemma 6.2: *Suppose $L = A$, then the optimal choice of effort of manager $m \in \{1, 2, ..., M\}$, denoted e^*_m, is a solution to the first order condition:*

$$(4.2)\; 2\left(1+\frac{\operatorname{cov}\left(\sum_{m=1}^{M-1}\tilde{e}_m, \tilde{e}_m \mid \tilde{I}\right)}{\operatorname{var}\left(\tilde{e}_m \mid \tilde{I}\right)}\right)^2 \left(1-\frac{d\,E\left[\tilde{e}_m \mid \tilde{I}\right]}{d\,\tilde{e}_m}\right)\frac{\Phi(\Phi+(M+1)\iota)}{(M+1)^2(\Phi+\iota)^2\lambda}\left(\tilde{e}_m - E\left[\tilde{e}_m \mid \tilde{I}\right]\right) = \frac{d\,E\left[\tilde{C}(\tilde{e}_m) \mid \tilde{e}_m, \tilde{c}, \tilde{I}\right]}{d\,\tilde{e}_m},$$

where λ is the price sensitivity. The second order condition secures that the found optimum is a maximum and equals

$$(4.3)\; 2\left(1+\frac{\operatorname{cov}\left(\sum_{m=1}^{M-1}\tilde{e}_m, \tilde{e}_m \mid \tilde{I}\right)}{\operatorname{var}\left(\tilde{e}_m \mid \tilde{I}\right)}\right)^2 \left(1-\frac{d\,E\left[\tilde{e}_m \mid \tilde{I}\right]}{d\,\tilde{e}_m}\right)^2 \frac{\Phi\,(\Phi + (M + 1)\,\iota)}{(M + 1)^2\,(\Phi + \iota)^2\,\lambda} < \frac{d^2\,E\left[\tilde{C}(\tilde{e}_m) \mid \tilde{e}_m, \tilde{c}, \tilde{I}\right]}{d\,\tilde{e}_m^2}.$$

If the corporate managers of firm $k \in \{1, 2, ..., K\}$ are of the same quality, the price sensitivity is given by (3.9) and the term $(1 + (\operatorname{cov}(\Sigma e_m, e_m \mid I) / \operatorname{var}(e_m \mid I))^2 = M^2$.

Proof: See appendix B.

A choice of effort satisfying (4.2) and (4.3) is an optimal choice of effort. Notice that if $\iota = 0$, the corporate manager is certain about the value impact of (total) effort on the future value of the security. Otherwise, the corporate manager becomes uncertain from time t_{-4} to time t_{-2}. In this way, time may make the corporate insiders uncertain about their own productive effort which, of course, has consequences for trading in the securities market.

Now suppose that

$$(4.4) \qquad \tilde{C}(\tilde{e}_m) = F + f(\tilde{e}_m - e_m)^2 + 2\tilde{c}(\tilde{e}_m - e_m),$$

where

$$(4.5) \qquad F, f, e_m \in \mathbf{R} \text{ and } \tilde{c} \sim N\left(E[\tilde{c} \mid \tilde{I}], \operatorname{var}(\tilde{c} \mid \tilde{I}) = \Theta\right).$$

This means that $C(e_m)$ is minimized when $e_m = e_m - (c / f)$ where $E[e_m - (c / f) \mid I] = e_m - (E[c \mid I] / f)$ and $E[E[e_m - (c / f) \mid I]] = e_m$ because $E[E[c \mid I]] = 0$. In this way, the cost function reflects that the corporate managers expect to pay the lowest individual cost of effort when they supply the pre-specified level of effort e_m. Supplying a different level of effort is expected to give greater costs because the managers then have to work hard or shrink where $C(e_m \to \pm\infty) \to \infty$. Shrinking is costly because it may hurt their long time reputation (see, e.g., Holmström (1992)). The reputation effect, however, is not explicitly modeled.

Lemma 6.3: *Suppose there is only one type of corporate managers in each firm (that is only one realization of c) and*

$$(4.6) \qquad f > \frac{M^2 \Phi (\Phi + (M + 1)\iota)}{(M + 1)^2 (\Phi + \iota)^2 \lambda},$$

then there may exist a choice of effort satisfying both (4.2) and (4.3). The optimal individual choice of effort is characterized by

$$\tilde{e}^*_m = e_m - \frac{(M+1)^2(\Phi+\iota)^2\lambda}{f(M+1)^2(\Phi+\iota)^2\lambda - M^2\Phi(\Phi+(M+1)\iota)}\,\tilde{c}, \tag{4.7}$$

which means that

$$\mathrm{var}(\tilde{e}_m \mid \tilde{I}) = \left(\frac{(M+1)^2(\Phi+\iota)^2\lambda}{f(M+1)^2(\Phi+\iota)^2\lambda - M^2\Phi(\Phi+(M+1)\iota)}\right)^2\Theta. \tag{4.8}$$

The variance of total effort $\Phi = M^2\ \mathrm{var}(e_m \mid I)$.

Proof: See appendix C.

We see that the variance of total effort is determined as part of the equilibrium, but $\Phi = M^2\ \mathrm{var}(e_m \mid I)$ turns out to be a rather complex equation in Φ. This is because $\mathrm{var}(e_m \mid I)$ depends non-linearly on Φ. However, numerical analyses indicate, given the restrictions that exogenous parameters are positive, that there tends to be only one real root greater than zero. No close form solution exists in general. I therefore introduce a somewhat strange restriction on the cost function in order to avoid analyzing the equilibrium numerically because it seems not to alter any results obtained by analyzing lemmas 6.1 - 6.3 numerically.

Assumption: *Let*

$$\iota = 0 \textit{ and } f = \frac{M^2 s}{(M+1)^2\lambda}, \tag{4.9}$$

where

$$s > 1 + (M+1)\sqrt{\frac{\Theta}{M\sigma}}. \tag{4.10}$$

This assumption reduces the equation $\Phi = M^2$ var(e_m | I) to an equation with a unique solution because Φ now enters linearly in var(e_m | I). Nonetheless, the private cost of effort depends on the number of corporate managers and the liquidity of the market.

Lemma 6.4: *Suppose (4.9) holds and there is only one type of managers in each firm, then the variance of total effort is unique:*

$$\Phi = \frac{(M+1)^2\left[N(\Gamma+\varepsilon) + M(\Gamma+\eta)\,\alpha^2\right]}{M\left[M(s-1)^2\sigma - (M+1)^2\Theta\right]a^2}\,\Theta, \tag{4.11}$$

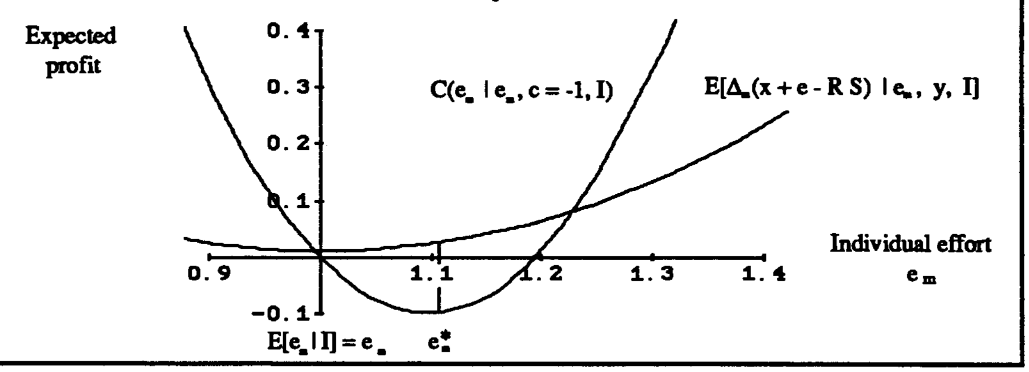
where α is given by (3.7) and a is given by (4.15) below. The individual effort is therefore

$$\tilde{e}_m^* = e_m - \frac{M+1}{M^2 a}\sqrt{\frac{M\left[N(\Gamma+\varepsilon) + M(\Gamma+\eta)\,\alpha^2\right]}{M(s-1)^2\sigma - (M+1)^2\Theta}}\;\tilde{c}. \tag{4.12}$$

<u>Proof</u>: I use the simplifying assumption (4.9) and then insert (3.9) into (4.8). The result is given by (4.11). Then I use (4.9) and insert (3.9) into (4.7), and get (4.12). Notice that (4.10) follows from (4.11) because Φ must be non-negative. Q.E.D.

Figure 6.2 illustrates how the optimal individual effort is determined by using the numerical values in table 6.4 (see appendix F).

FIGURE 6.2 Optimal effort



The optimal effort $e_m^* = 1.113 > e_m = 1.000$ because the corporate manager is assumed to be of type $c = -1 < E[c \mid I] = 0$. The total expected profit (evaluated before y is realized) is 0.124. Thus, the managers of above average quality supply more effort than expected. They may therefore expect to earn an abnormal return on inside information. This type of equilibrium is later called incentive compatible.

Corollary 6.3: If $\Theta = 0$ or $s \to \infty$, $\Phi = 0$ and $e^*_m = e_m$.

Proof: This follows directly from (4.11) (and (4.12)). According to (2.5), if $\varphi = 0$, $\Theta = 0$ because then the market knows the type of the managers in firm k. Q.E.D.

This suggests that if it is very costly to surprise the securities market by supplying an effort different from what is expected, the corporate managers do as the market expects (before the signal $y_\bullet$ is realized; see (4.13) below). If $\Theta = 0$, the managers are not able to surprise the market because their quality and thereby their effort is publicly known.

Lemma 6.5: *Given (4.9) and that e^*_m is equal for all managers in firm k, there exists a unique trading equilibrium $[(\theta_{nkt}, \Delta_{mkt}, u_{kt}), S_{kt};\ n \in \{1, 2, ..., N\}, m \in \{1, 2, ..., M\}, k \in \{1, 2, ..., K\}, t \in \{0, 1, ..., T_k - 1\}]$ where the trading strategies are given by (3.1) - (3.2) and the transaction price is given by (3.8) where rational expectations means that*

$$(4.13) \qquad E[\tilde{e} \mid I] = M\left[e_m - \frac{M + 1}{M^2 a}\sqrt{\frac{M\left[N(\Gamma + \varepsilon) + M(\Gamma + \eta)\alpha^2\right]}{M(s - 1)^2\sigma - (M + 1)^2\Theta}}\ E[\tilde{c} \mid I]\right].$$

The trading intensities are

$$(4.14) \qquad \beta = \frac{1}{s - 1}\sqrt{\frac{M(s - 1)^2\sigma - (M + 1)^2\Theta}{M\left[N(\Gamma + \varepsilon) + M(\Gamma + \eta)\alpha^2\right]}},$$

$B = \alpha\,\beta$, and $b = a\,\beta$ where α is given by (3.7) and

(4.15) $$a = \frac{N\Gamma + (M+1)(\Gamma+\eta)\,\alpha}{(M+1)\,\Gamma}.$$

The price sensitivity is

(4.16) $$\lambda = \frac{s-1}{(M+1)\,a}\sqrt{\frac{M\left[N(\Gamma+\varepsilon) + M(\Gamma+\eta)\,\alpha^2\right]}{M(s-1)^2\,\sigma - (M+1)^2\,\Theta}}.$$

Proof: I use assumption (4.9) and insert (4.11) into (3.3), (3.6), and (3.9). The given results follows straightforwardly. Rational expectations mean that $E[E[e_m \mid I]] = e_m$ and when $y_\bullet$ is realized at time t_{-3}, the value is adjusted as shown in (4.13). Q.E.D.

Together lemmas 6.4 - 6.5 form a production and exchange equilibrium. It is used in the following sections to discuss insider trading on effort generated information.

Corollary 6.4: *If $\Theta = 0$ or $s \to \infty$, the trading intensities of informed speculators are given by (2.3.3) and (2.3.4). The price sensitivity is given by (4.3.8).*

Proof: This follows directly from (3.5), (4.14), and (4.16). Notice that $b > 0$, but the demand caused by effort generated information is zero. Q.E.D.

Naturally, when the cost of surprising the market is very high, there would be no effort surprise and therefore no demand caused by effort generated information. We are back in the securities market setting studied in chapters 2 - 4.

6.5 ON THE PROPERTIES OF THE EQUILIBRIUM

This section analyzes the equilibrium characterized by lemmas 6.4 - 6.5, but focuses most on the individual choice of effort.

On the managers` choice of effort

The managers` individual choice of effort is stochastic to outsiders, but known to all the corporate managers in a particular firm.

Proposition 6.1: *There exist two types of effort choices. An incentive compatible choice of effort is defined as $e^*_m > E[e_m / I]$ and a destructive choice of effort is defined as $e^*_m < E[e_m / I]$. With insider trading as the sole incentive mechanism, the probability of ending up in a incentive compatible choice equals the probability of ending up in a destructive choice of effort (or investment policy).*

<u>Proof</u>: The two types of effort choices follow directly from (4.12), and the probability of ending up below its expectations equals 1/2 because e_m is normally distributed from the outsiders` point of view. Q.E.D.

Corporate managers generate inside information by choosing an effort that surprises the securities market. If the managers is of type $c < 0$, they supply more effort than expected. Such managers are therefore of high quality. On the other hand, if the managers are more effort averse ($c > 0$), they supply less than expected. Thus, an optimal effort strategy motivated by insider trading implies making effort stochastic to keep the market uncertain about the supply of effort.

Proposition 6.2: *The optimal amount of individual effort (and thereby the total effort) increases with the market`s expectation about individual effort and decreases with the corporate manager`s realized cost of supplying effort.*

Proof: This follows directly by differentiating (4.12) with respect to the relevant variables (which is $E[E[e_m \mid I]] = e_m$ and c). Q.E.D.

Measured in expectation, effort is supplied because the financial market expects that the managers to work. If L = A, the corporate managers always try to surprise the market to generate inside information. A higher realized cost of supplying effort leads to less supply.

Proposition 6.3: *For a given expectation of effort and a given realized cost of supplying effort, the total effort surprise measured by Φ has these unique comparative statics:*

$$\frac{d\Phi}{d\sigma} < 0,\ \frac{d\Phi}{d\Theta} > 0,\ \textit{and}\ \frac{d\Phi}{ds} < 0. \tag{5.1}$$

The rest of the comparative statics may both be larger and less then zero depending on the size of the exogenous parameters involved.

Proof: I use the closed form solution given by (4.11). The comparative statics are obtained by differentiating with respect to the relevant variables. Q.E.D.

For instance, if **s**, which represents the cost of making effort increases, the amount of effort generated information Φ is reduced.

Short on the properties of the trading equilibrium

The properties of the trading equilibrium are analyzed in chapters 3 - 4 using the limit given by corollary 6.1 above. Nonetheless, there are some interesting aspects about the more general trading equilibrium which give additional insight.

The price sensitivity and thereby the equilibrium bid ask spread depend on the adverse selection problem faced by the price setting market makers. In this chapter, there are two independent adverse selection problems.

The first is created solely by the corporate insiders because they observe effort generated information. The second adverse selection problem is created by the corporate insiders and the market professionals together because they both observe information about business fluctuations.

The market efficiency is the ability of the transaction price to transmit information from informed to uninformed.

Lemma 6.6: *The price informativeness is*

$$(5.2) \quad \Psi = \frac{M(M+1)\left[M(s-1)^2\sigma - (M+1)^2\Theta\right]a^2}{M\left[M(s-1)^2\sigma-(M+1)^2\Theta\right](\Gamma+2\varepsilon)\,a + (M+1)^2\left[N(\Gamma+\varepsilon)+M(\Gamma+\eta)\,\alpha^2\right]\Theta}.$$

Proof: A measure of market efficiency is $\Psi = 1 / \mathrm{var}(x + e \mid S, I)$, and (5.2) follows directly from the structure of the equilibrium. Q.E.D.

The price informativeness tends to increase with the supply of corporate insiders since they reveal both effort generated information and information about business fluctuations. Notice that because of risk neutrality, the noise traders do not affect market efficiency.

Corollary 6.5: *If $s \to \infty$ or $\Theta = 0$, then the price informativeness is given by (3.5.7). In addition, $d\,\Psi / d\,s > 0$.*

Proof: The limits and the comparative static follow directly from (5.2). Q.E.D.

For instance, if $\Theta = 0$, then the quality of corporate managers is publicly known and, as long as the market is semi-strong efficient, the transaction price always reflects such information. The market efficiency increases with the cost of acquiring effort generated information because less superior information is produced by the corporate managers.

6.6 WELFARE EFFECTS

Table 6.2 gives the expected profit of stable owners, owners which in addition trade to satisfy their liquidity needs (such as hedging), pure liquidity traders, market professionals, corporate insiders, and market makers at time t_4.

TABLE 6.2:	Expected profit
Stable owners	$(1 - v)\,E[\tilde{x} + \tilde{e} \mid \tilde{I}]$
Liquidity trading owners	$v\,E[\tilde{x} + \tilde{e} \mid \tilde{I}] - w\,\lambda\,\mathrm{cov}(\tilde{u}, \tilde{z} \mid \tilde{I})$
Pure liquidity traders	$-(1 - w)\,\lambda\,\mathrm{cov}(\tilde{u}, \tilde{z} \mid \tilde{I})$
Market professionals	$N\left\{\mathrm{cov}(\tilde{\theta}_n, \tilde{x} + \tilde{e} \mid \tilde{I}) - \lambda\,\mathrm{cov}(\tilde{\theta}_n, \tilde{z} \mid \tilde{I})\right\}$
Insiders	$M\left\{\mathrm{cov}(\tilde{\Delta}_m, \tilde{x} + \tilde{e} \mid \tilde{I}) - \lambda\,\mathrm{cov}(\tilde{\Delta}_m, \tilde{z} \mid \tilde{I}) - \left[F + f\,\mathrm{var}(\tilde{e}_m \mid \tilde{I}) + 2\,\mathrm{cov}(\tilde{e}_m, \tilde{c} \mid \tilde{I})\right]\right\}$
Market makers	$\lambda\,\mathrm{var}(\tilde{z} \mid \tilde{I}) - \mathrm{cov}(\tilde{x} + \tilde{e}, \tilde{z} \mid \tilde{I})$
Total	$E[\tilde{x} \mid \tilde{I}] + M\left\{E[\tilde{e}_m \mid \tilde{I}] - \left[F + f\,\mathrm{var}(\tilde{e}_m \mid \tilde{I}) + 2\,\mathrm{cov}(\tilde{e}_m, \tilde{c} \mid \tilde{I})\right]\right\}$

The total profit available to the participants is the expected future value of the firm minus the expected cost of supplying effort.

Lemma 6.7: *The total expected profit to stable owners, liquidity trading owners, pure liquidity traders, market professionals, corporate managers, and market makers are*

$$(6.1) \qquad E\left[(1 - v)\sum_{o=1}^{O}\tilde{\pi}_o^O \mid \tilde{I}\right] = (1 - v)\,E[\tilde{x} + \tilde{e} \mid \tilde{I}],$$

$$E\left[v \sum_{o=1}^{O} \tilde{\pi}_o^O + w \sum_{d=1}^{D+1} \tilde{\pi}_d^{D+1} \mid \tilde{I}\right] = v\, E\left[\tilde{x} + \tilde{e} \mid \tilde{I}\right] - w\, \lambda\, \sigma, \tag{6.2}$$

$$E\left[(1 - w) \sum_{d=1}^{D+1} \tilde{\pi}_d^{D+1} \mid \tilde{I}\right] = -(1 - w)\, \lambda\, \sigma, \tag{6.3}$$

$$E\left[\sum_{n=1}^{N} \tilde{\pi}_n^N \mid \tilde{I}\right] = \frac{N(\Gamma + \varepsilon)}{(M + 1)^2\, a^2\, \lambda}, \tag{6.4}$$

$$E\left[\sum_{m=1}^{M} \tilde{\pi}_m^M \mid \tilde{I}\right] = M\left\{\frac{(M + 1)^2\, \lambda}{M^2\, (s - 1)}\, \Theta + \frac{\alpha^2\, (\Gamma + \eta)}{(M + 1)^2\, a^2\, \lambda} - F\right\}, \textit{ and} \tag{6.5}$$

$$E\left[\sum_{q=1}^{Q} \tilde{\pi}_q^Q \mid \tilde{I}\right] = 0, \tag{6.6}$$

where α is given by (3.7), a is given by (4.15), and λ is given by (4.16).

Proof: Equations (6.1) - (6.6) follow straightforwardly from the setup in table 6.2. Note that this is a special case of lemma 6.9 with a more elaborate proof given in appendix D. Q.E.D.

As we see, the expected profit of most participants depends, either directly or indirectly through the price sensitivity, on the managers' cost of supplying an effort different from what is expected.

Corollary 6.6: *If $w = 0$, $F = 0$, and either $s \to \infty$ or $\Theta = 0$, the expected profit of market professional $n \in \{1, 2, ..., N\}$ and corporate insider $m \in \{1, 2, ..., M\}$ is given by (4.2.2) and (4.2.3) respectively. The total expected profit of the $D + 1$ liquidity traders is given by (4.2.9).*

Proof: This follows straightforwardly from (6.3), (6.4), and (6.5). Q.E.D.

If it is too costly to surprise the security market by supplying an unexpected effort, this, of course, implies that the corporate insiders do not profit from effort generated information simply because they do not have any. In this case, the price sensitivity (or the bid ask spread) only reflects the adverse selection caused by superior information about business fluctuations, leaving the market professionals and the liquidity traders with the same trading cost as in chapter 4.

Proposition 6.4: *If s increases, the welfare of market professionals, liquidity trading owners, and pure liquidity traders increases. The welfare of stable owners is unchanged. The welfare of corporate insider may both increase and decrease. If, for example, s increases from s• (where s• is a large constant), the welfare of corporate insiders decreases.*

Proof: It follows from (4.15) that λ decreases in s. We see directly from (6.2), (6.3), and (6.4) that the welfare of liquidity trading owners, pure liquidity traders, and market professionals increases. The welfare of corporate insiders depends on their two sources of information. If s increases, the expected profit on effort generated information decreases, but the expected profit on information about random fluctuations increases. However, if s > s• (suggesting that s has to be large), the expected effect on the expected profit from insider trading on Y dominates the expected effect on the expected profit from y. Q.E.D.

This suggests that one way of reducing the expected gains which the corporate managers have earned on insider trading is to make it more costly for them to trade on effort generated information; see section 6.9 for an approach where the current shareholders control the corporate managers by punish them for unexpected outcomes.

6.7 OPTIMAL CHOICE OF BUSINESS RISK

I have in the previous sections assumed that the risk caused by random business fluctuations is given exogenously. Nonetheless, the corporate managers may influence these fluctuations through their selection of new projects. This section is used, within the framework of the outlined model, to discuss how managers should select new investment projects in order to maximize their own expected profit by trading in the securities market.

The effort selection problem of corporate manager m $\in$ {1, 2, ..., M} is given by (4.1). It is easy to extend to a setting which includes a (collective) choice of business risk represented by Γ. Thus, the extended decision problem of manager m is to

$$(7.1) \qquad \underset{\substack{\tilde{e}_m, \\ \Gamma \in [\Gamma_{MIN}, \Gamma_{MAX}]}}{\text{Max}} \; E\Big[\tilde{\Delta}_m \big[(\tilde{x} + \tilde{e}) - R\,\tilde{S}\big] - \tilde{C}(e_m) \mid \tilde{e}_m, \tilde{c}, \tilde{I}\Big],$$

which, according to (6.5), is equivalent to

$$(7.2) \qquad \underset{\Gamma \in [\Gamma_{MIN}, \Gamma_{MAX}]}{\text{Max}} \; \frac{(M + 1)^2 \lambda_\Gamma}{M^2 (s - 1)} \Theta + \left(\frac{\alpha_\Gamma}{a_\Gamma}\right)^2 \frac{\Gamma + \eta}{(M + 1)^2 \lambda_\Gamma} - F,$$

where the subscript indicates which expressions that depend on Γ. I have implicitly assumed that there are no managerial costs of choosing a riskier technology, implying, e.g., that the principals do not punish the managers for selecting a risky before a safer technology and that there are no reputation effects, and that the managers' optimal choice of technology, denoted Γ^*, is public. Figure 6.3 illustrates the optimal choice of business risk given the numerical parameters in table 6.4 (see appendix F).

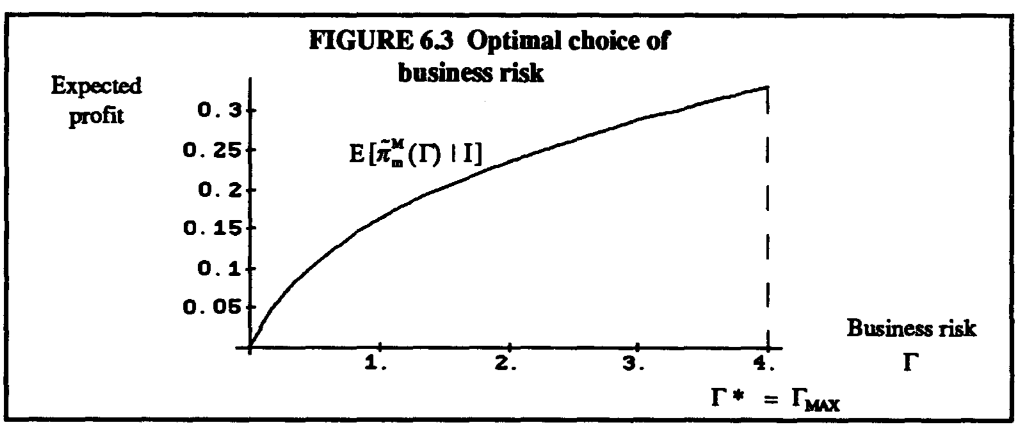


FIGURE 6.3 Optimal choice of business risk

The optimal strategy is to select the portfolio of projects that makes the firm as risky as possible, meaning that $\Gamma^* = \Gamma_{MAX} = 4$. However, if the managers, as in the next section are punished if they select too risky projects, their expected profit may decrease in the amount of business risk.

Proposition 6.5: *The corporate managers tend to select risky projects before safer projects. Thus,* $\Gamma^* = \Gamma_{MAX}$.

Proof: The price sensitivity tends according to (4.16) to increase with the riskiness of the firm (i.e., $d\lambda_\Gamma / d\Gamma > 0$). This means that the first term in (7.2) increases with Γ. The effect on the second term is more ambiguous, but the direct effect on Γ tends to dominate. This implies that also the second term is increasing in the riskiness of the firm. Q.E.D.

This is consistent with Leftwich and Verrecchia (1983). They conclude that the value of information is an increasing function of the variance of the outcome. This implies that superior information is generated if something unexpected happens, and unexpected events such as random business fluctuations happen more often to risky projects.

This suggests that there is an important difference between information generated through effort and more random information. The reason is that effort created information may have positive incentive effects which is hardly obtainable with information not directly controlled by the managers. Regulators hunting illegally trading insider should therefore concentrate on quasi-insiders such as tippees who have obtained their information without supplying any effort.

6.8 INSIDER TRADING AS AN INCENTIVE MECHANISM

This section compares the insider trading equilibrium with two related equilibria. They are obtained in a similar production and exchange setting, except for the fact that insider trading is effectively forbidden (that is, $L = \mathbf{B}$ and $\mu = 0$). Instead the corporate managers are compensated through a linear sharing rule, but the securities market is still open so that the other traders, including the market professionals trading on private information, may satisfy their demand. The first of these equilibria is first best efficient (or Pareto-optimal) as the principals directly observe the abilities of their agents, and pay them just the cost of supplying the desired effort. In the second equilibrium, the managerial type and thereby their choice of effort are not directly observed by the principals. This implies that the principals face both an adverse selection (hidden information) and a moral hazard problem (hidden action), giving the corporate managers an informational advantage which is an opportunity to maximize their own expected profit. The principals are assumed to effectively prohibit insider trading, and are instead using a linear sharing rule to motivate the agents to supply the desired level of productive effort.

First best

Now assume that the type or quality of corporate managers and thereby their effort are perfectly observable by the principals. This suggests that the hired agents have to select the effort that maximize the liquidation value of the firm minus their cost of supplying the desired level of effort. In this way, corporate manager $m \in \{1, 2, ..., M\}$ has to

$$\text{(8.1)} \qquad \underset{\tilde{e}_m}{\text{Max}}\ E\left[\tilde{x} + \tilde{e}_m + \sum_{m=1}^{M-1} e_m - \tilde{C}(\tilde{e}_m) \mid \tilde{e}_m, \tilde{c}, \tilde{I}\right],$$

where $C(e_m)$ is the private cost function given by (4.4). The term e_m in (4.4) may be interpreted as the effort supplied by a manager of average quality which is assumed to be unaffected by actions from the principals. This assumption means that e_m is a publicly known constant. The first best effort is determined by the first order condition:

$$\text{(8.2)} \qquad \tilde{e}_m^{**} = e_m - \frac{2\tilde{c} - 1}{2f}.$$

This choice of effort is first best efficient (or Pareto-optimal) because the marginal revenue equals the marginal cost of supplying effort. If c is observable, the principals, paying the agents no more than the cost of supplying the desired level of effort, would like a corporate manager to supply an effort greater than average if the manager's quality is higher than average (that is when $c < 0$) and vice versa. Finally, notice that the first best effort decreases if the cost of supplying effort increases.

Second best

Instead assume that the principals cannot directly observe the type or quality of their corporate managers. However, the principals observe the output at time t+1 which according to (2.1) is influenced by a random term. Then the principals offer the managers a linear sharing rule, and they accept the offered contract if it gives a positive expected profit (which means that the participation constraint is fulfilled). In this way, the problem of manager $m \in \{1, 2, ..., M\}$ is to

$$\text{(8.3)} \qquad \underset{\tilde{e}_m}{\text{Max}}\ E\left[\bar{A} + \mathbf{b}\left(\tilde{x} + \tilde{e}_m + \sum_{m=1}^{M-1} e_m\right) - \tilde{C}(\tilde{e}_m) \mid \tilde{e}_m, \tilde{c}, \tilde{I}\right],$$

where $\bar{A}, \mathbf{b} \in \mathbf{R}$. The first order condition gives

$$\text{(8.4)} \qquad \tilde{e}^{*}_{m} = e_m - \frac{2\,\tilde{c} - \mathbf{b}}{2\,f}.$$

The individual second best choice of effort when $L = \mathbf{B}$ is normally distributed with expectation e_m - (2 E[c | I] - $\mathbf{b}$) / 2 f and variance $(1 / f)^2\, \Theta$.

Proposition 6.6: *If $b < 1$, then $e^{*}_{m} < e^{**}_{m}$, and if $b = 1$, $e^{*}_{m} = e^{**}_{m}$. The expected individual production increases with b.*

<u>Proof</u>: This follows by comparing equation (8.2) with (8.4). The last sentence follows because $d\, e^{*}_{m} / d\, \mathbf{b} > 0$. Q.E.D.

This is a version of the result obtained by Holmström (1979) and Shavell (1979). Proposition 1 in the last article implies that if the agents are risk neural, there exists a Pareto-optimal fee schedule under which the agents are paid the outcome minus a constant.

L = A vs L = B with an linear outcome-contingent incentive scheme

If insider trading is allowed (L = A), the individual effort of corporate manager $m \in \{1, 2, ..., M\}$ is given by (4.7). This effort is

(8.5) $$\tilde{e}^*_m = e_m - \frac{\tilde{c}}{f - k},$$

in which $f > k$ (see (4.6)) where k is a constant which is determined by market variables such as liquidity and the number of corporate insiders.

Proposition 6.7: *Suppose f is given by (4.9), then insider trading as an incentive mechanism is first best efficient if*

(8.6) $$\tilde{c} = \frac{1 - s}{2} < 0,$$

where s represents the cost of surprising the market. Nevertheless, the probability that insider trading is a first best efficient incentive scheme is zero.

Proof: I set (8.5) equal to (8.2), and yield (8.6). Because c is stochastic and continuous, the probability that c equals one particular value is zero. Q.E.D.

If the corporate managers are of this particular quality higher than average, they are induced to supply the first best effort. Otherwise, their supply is not efficient.

Proposition 6.8: *Suppose*

(8.7) $$\mathbf{b} > - \frac{2}{s - 1} E\left[\tilde{c} \mid \tilde{I}\right],$$

then

(8.8) $$E\left[\tilde{e}_m \mid \tilde{I}, L = \mathbf{B}\right] > E\left[\tilde{e}_m \mid \tilde{I}, L = \mathbf{A}\right].$$

*Nevertheless, for all **b**,*

(8.9) $$\mathrm{var}\left(\tilde{e}_m \mid \tilde{I}, L = \mathbf{B}\right) = \frac{1}{f^2} \Theta < \mathrm{var}\left(\tilde{e}_m \mid \tilde{I}, L = \mathbf{A}\right) = \frac{1}{(f - \mathbf{k})^2} \Theta.$$

<u>Proof</u>: These inequalities follow easily from $e^{\bullet}_m$ and e^*_m which are given by equations (8.4) - (8.5). Notice that

(8.10) $$E\left[\tilde{e}_m \mid \tilde{I}, L = \mathbf{B}\right] = E\left[\tilde{e}_m \mid \tilde{I}, L = \mathbf{A}\right] + \frac{\mathbf{k}\, E\left[\tilde{c} \mid \tilde{I}\right]}{f(f - \mathbf{k})} + \frac{\mathbf{b}}{2f},$$

and condition (8.7) follows straightforwardly by setting the two last terms greater than zero and solve for **b**. Q.E.D.

If $E[c \mid I] = 0$ and $\mathbf{b} = 0$, implementing insider trading as an incentive mechanism gives the same expected effort as prohibiting insider trading. Nonetheless, if the insiders are initially expected to be of high quality (which means that $E[c \mid I] < 0$), insider trading indeed has positive incentive effects, but the same incentive effects can be obtained without insider trading by increasing **b**. Finally, notice that the variance of effort always increases with insider trading.

I conclude that risk neutral principals prefer insider trading prohibited and replaced by a linear outcome-contingent incentive scheme $\bar{A} + \mathbf{b}\,(x + e)$. In addition, it is easy in this risk neutral economy to implement a first best efficient incentive scheme by setting $\mathbf{b} = 1$. This result contrasts the one obtained by Manne (1966) who claims that insider trading is an efficient incentive scheme. Nevertheless, insider trading may be desirable to risk averse principals because a (large) position taken by corporate insiders may improve the risk sharing as shown by Dye (1984); see chapter 8 for further comments.

6.9 OPTIMAL CONTROL OF INSIDER TRADING

In this section the cost function given by (4.4) is slightly changed to give further insight into the equilibrium forces which are present in securities markets allowing insider trading. Specifically the quadratic term in individual effort is replaced by a quadratic term in output to reflect that the principals may try to confiscate some of the gains from insider trading. Thus,

$$\tilde{C}(\tilde{e}_m) = f\left(\tilde{x} + \tilde{e} - E\left[\tilde{x} + \tilde{e} \mid \tilde{I}\right]\right)^2 + 2\,\tilde{c}\,(\tilde{e}_m - e_m) + F, \tag{9.1}$$

in which the first term is a fee paid by each manager to the current shareholders for the right of trading on inside information and the two last terms represent the manager's individual cost of supplying the effort e_m. The corporate managers have to pay a fee because inside information is expected to have a relatively high value, and consequently the current shareholders design a mechanism which transfer some of it to them. The part of the cost function reflecting the cost of effort equals F if the manager's choice of effort is e_m which in equilibrium is the market's expectation about the manager's supply of effort. If the manager is of a type which appreciates making effort, realized $c < 0$, and if the manager is of a type which does not like to make effort, $c > 0$.

Equilibrium

The trading intensities and the price sensitivity turn out to be identical to the ones produced by the cost function given by (4.4), but as we shall see, the distribution of expected profit has changed because of the transfer from corporate managers to their principals.

Lemma 6.8: If (9.1) replaces (4.4) and f is given by (4.9), the equilibrium parameters Φ, b, B, β, and λ equal the ones given in by lemmas 6.4 - 6.5.

The proof mimics the ones of lemma 6.4 and 6.5 and is therefore omitted. The current shareholders control the managers` payment through s. They may therefore reduce the effort surprise by increasing s.

Proposition 6.9 *By choosing s very large, the current shareholders may eliminate the effort surprise and thereby the amount of effort generated information.*

<u>Proof</u>: According to (4.11),

$$\lim_{s \to \infty} \Phi(s) = 0. \tag{9.2}$$

The effort surprise and the amount of effort generated information are measured by Φ and are therefore eliminated. Q.E.D.

If s approaches infinity, the corporate managers are forced to stop the production of effort generated information. They do this by always choosing the action expected by the securities market. Nevertheless, the next subsection shows that such a choice of s is not consistent with a long term equilibrium as corporate managers have no incentive to participate. But some punishment is always optimal at least to satisfy the viability condition given by (4.10).

Welfare

Table 6.3 gives the expected profit of all the participants in the production and exchange economy summarized by lemmas 6.4 - 6.5 when the transfer of money from the managers to the shareholders is taken into consideration. Compare with table 6.2 above.

TABLE 6.3:	Expected profit
Stable owners	$(1 - v)\left\{E\left[\tilde{x} + \tilde{e} \mid \tilde{I}\right] + M f \operatorname{var}\left(\tilde{x} + \tilde{e} \mid \tilde{I}\right)\right\}$,
Liquidity trading owners	$v\left\{E\left[\tilde{x} + \tilde{e} \mid \tilde{I}\right] + M f \operatorname{var}\left(\tilde{x} + \tilde{e} \mid \tilde{I}\right)\right\} - w \lambda \operatorname{cov}\left(\tilde{u}, \tilde{z} \mid \tilde{I}\right)$,
Pure liquidity traders	$-(1 - w) \lambda \operatorname{cov}\left(\tilde{u}, \tilde{z} \mid \tilde{I}\right)$,
Market professionals	$N\left\{\operatorname{cov}\left(\tilde{\theta}_n, \tilde{x} + \tilde{e} \mid \tilde{I}\right) - \lambda \operatorname{cov}\left(\tilde{\theta}_n, \tilde{z} \mid \tilde{I}\right)\right\}$,
Insiders	$M\left\{\operatorname{cov}\left(\tilde{\Delta}_m, \tilde{x} + \tilde{e} \mid \tilde{I}\right) - \lambda \operatorname{cov}\left(\tilde{\Delta}_m, \tilde{z} \mid \tilde{I}\right) - \left[F + f \operatorname{var}\left(\tilde{x} + \tilde{e} \mid \tilde{I}\right) + 2 \operatorname{cov}\left(\tilde{e}_m, \tilde{c} \mid \tilde{I}\right)\right]\right\}$
Market makers	$\lambda \operatorname{var}\left(\tilde{z} \mid \tilde{I}\right) - \operatorname{cov}\left(\tilde{x} + \tilde{e}, \tilde{z} \mid \tilde{I}\right)$
Total	$E\left[\tilde{x} \mid \tilde{I}\right] + M\left[E\left[\tilde{e} \mid \tilde{I}\right] - \left\{F + 2 \operatorname{cov}\left(\tilde{e}_m, \tilde{c} \mid \tilde{I}\right)\right\}\right]$

The total expected profit is the outcome at time t+1 minus the cost of making effort. Notice, however, that if F is small, the total cost of making effort is expected to be positive because $\operatorname{cov}(e_m, c \mid I) < 0$. With F small, the realized cost is always positive in equilibrium as the corporate managers who enjoy making effort (realized $c < 0$) always supply a positive amount of effort whereas the managers who find effort costly (realized $c > 0$) instead supply an effort less than expected. A supply less than expected pleases these managers and therefore gives a positive contribution to the expected welfare.

Lemma 6.9: *The total expected profit to stable owners, liquidity trading owners, pure liquidity traders, market professionals, corporate managers, and market makers are*

$$(9.3)\quad E\left[(1 - v)\sum_{o=1}^{O} \tilde{\pi}_o^{O} \mid \tilde{I}\right] = (1 - v)\left\{E\left[\tilde{x} + \tilde{e} \mid \tilde{I}\right] + \frac{M s}{(M + 1)^2 \lambda}\left(\Gamma + \left[\frac{(M + 1)^2 \lambda}{M(s - 1)}\right]^2 \Theta\right)\right\},$$

$$(9.4)\ E\left[v\sum_{o=1}^{O}\tilde{\pi}_o^O + w\sum_{d=1}^{D+1}\tilde{\pi}_d^{D+1} \mid \tilde{I}\right] = v\left\{E\left[\tilde{x} + \tilde{e} \mid \tilde{I}\right] + \frac{Ms}{(M+1)^2\lambda}\left(\Gamma + \left[\frac{(M+1)^2\lambda}{M(s-1)}\right]^2\Theta\right)\right\} - w\lambda\sigma,$$

$$(9.5)\qquad E\left[(1-w)\sum_{d=1}^{D+1}\tilde{\pi}_d^{D+1} \mid \tilde{I}\right] = -(1-w)\lambda\sigma,$$

$$(9.6)\qquad E\left[\sum_{n=1}^{N}\tilde{\pi}_n^N \mid \tilde{I}\right] = \frac{N(\Gamma + \varepsilon)}{(M+1)^2 a^2 \lambda},$$

$$(9.7)\qquad E\left[\sum_{m=1}^{M}\tilde{\pi}_m^M \mid \tilde{I}\right] = M\left[\frac{(M+1)^2\lambda}{M^2(s-1)}\Theta + \frac{\alpha^2(\Gamma+\eta) - a^2 s\Gamma}{(M+1)^2 a^2\lambda} - F\right], \textit{ and}$$

$$(9.8)\qquad E\left[\sum_{q=1}^{Q}\tilde{\pi}_q^Q \mid \tilde{I}\right] = 0,$$

where α is given by (3.7), a is given by (4.15), and λ is given by (4.16).

Proof: See appendix D.

We observe that the expected profit of most participants depends on the current shareholders' punishment of outcomes different from what is expected.

Corollary 6.7: *The expected profit of various traders have the following values when s approaches its two limits:*

$$(9.9)\qquad \lim_{\substack{s \to \infty \\ s \to 1+(M+1)\sqrt{\frac{\Theta}{M\sigma}}}} E\left[(1-v)\sum_{o=1}^{O}\tilde{\pi}_o^O(s) \mid \tilde{I}\right] \to +\infty,$$

$$(9.10)\qquad \lim_{\substack{s \to \infty \\ s \to 1+(M+1)\sqrt{\frac{\Theta}{M\sigma}}}} E\left[v\sum_{o=1}^{O}\tilde{\pi}_o^O(s) + w\sum_{d=1}^{D+1}\tilde{\pi}_d^{D+1}(s) \mid \tilde{I}\right] \to +\infty,$$

$$\text{(9.11)} \qquad \lim_{s\to\infty} E\left[(1 - w)\sum_{d=1}^{D+1}\tilde{\pi}_d^{D+1}(s) \mid \tilde{I}\right] = -(1 - w)\,\sigma \lim_{s\to\infty}\lambda(s) < 0,$$

$$\lim_{s \to 1+(M+1)\sqrt{\frac{\Theta}{M\sigma}}} E\left[(1 - w)\sum_{d=1}^{D+1}\tilde{\pi}_d^{D+1}(s) \mid \tilde{I}\right] \to -\infty,$$

$$\text{(9.12)} \qquad \lim_{s\to\infty} E\left[\sum_{n=1}^{N}\tilde{\pi}_n^{N}(s) \mid \tilde{I}\right] = \frac{\Gamma}{N\Gamma + (M + 1)(\Gamma + \eta)\,\alpha} \lim_{s\to\infty}\beta(s) > 0,$$

$$\lim_{s \to 1+(M+1)\sqrt{\frac{\Theta}{M\sigma}}} E\left[\sum_{n=1}^{N}\tilde{\pi}_n^{N}(s) \mid \tilde{I}\right] = 0,$$

$$\text{(9.13)} \qquad \lim_{s\to\infty} E\left[\sum_{m=1}^{M}\tilde{\pi}_m^{M}(s) \mid \tilde{I}\right] \to -\infty, \textit{ and } \lim_{s \to 1+(M+1)\sqrt{\frac{\Theta}{M\sigma}}} E\left[\sum_{m=1}^{M}\tilde{\pi}_m^{M}(s) \mid \tilde{I}\right] \to +\infty.$$

Proof: According to (4.16),

$$\text{(9.14)} \qquad \lim_{s\to\infty}\lambda(s) = \frac{\Gamma}{N\Gamma + (M + 1)(\Gamma + \eta)\,\alpha}\sqrt{\frac{N(\Gamma + \varepsilon) + M(\Gamma + \eta)\,\alpha^2}{\sigma}}, \text{ and}$$

$$\lim_{s \to 1+(M+1)\sqrt{\frac{\Theta}{M\sigma}}} \lambda(s) \to +\infty.$$

The limits (9.9) - (9.13) follow directly by taking the respective limits of (9.3) - (9.7), being aware of the two limits for λ. Q.E.D.

When insider trading is allowed, then according to (4.10), the current shareholders have to punish corporate managers if the future value of the firm differs from what is expected by the market before trading to obtain a viable equilibrium. This means that current shareholders have to determine s at time t_{-4} presumably to maximize their expected profit. The result above indicates that the optimal selection of s is $s^* = 1 + (M + 1)(\Theta / M\,\sigma)^{1/2}$ or $s^* \to \infty$, but this is not the case.

Proposition 6.10: *If $s = 1 + (M + 1)(\Theta / M\,\sigma)^{1/2}$ or $s \to \infty$, then the market given by corollaries 6.3 - 6.4 collapses.*

Proof: If s approaches its lower limit, the market collapses because the pure liquidity traders expect to lose an infinite amount of money caused by the fact that the equilibrium bid ask spread approaches infinity (see (9.11) and (9.14)). Losing an infinite amount is not consistent with equilibrium behavior. If s approaches infinity, the corporate managers expect to lose an infinite amount of money (see (9.13)). This means that there are nobody who are willing to act as corporate managers. Q.E.D.

The non-existence of an equilibrium at the limits suggests that current shareholders have to determine s within certain bounds.

Optimal selection of s

The structure of the scheme punishing the corporate managers for unexpected outcomes is given by the first term in (4.4) where f is assumed to satisfy (4.9). This implies that the only parameter left for the current shareholders to decide is s. In this way, their maximization problem is

$$(9.15) \qquad \underset{s > 1+(M+1)\sqrt{\frac{\Theta}{M\sigma}}}{\text{Max}} E\left[\tilde{x} + \tilde{e} + \frac{M\,s}{(M+1)^2\,\lambda}\left(\tilde{x} + \tilde{e} - E\left[\tilde{x} + \tilde{e} \mid \tilde{I}\right]\right)^2 + w\,\tilde{u}\left(\tilde{x} + \tilde{e} - R\,\tilde{S}\right) \mid \tilde{I}\right],$$

subject to the participation constraints

$$(9.16)\ E\left[\tilde{\Delta}_m\left(\tilde{x} + \tilde{e} - R\,\tilde{S}\right) - \frac{s}{(M+1)^2\,\lambda}\left(\tilde{x} + \tilde{e} - E\left[\tilde{x} + \tilde{e} \mid \tilde{I}\right]\right)^2 - 2\,\tilde{c}\left(\tilde{e}_m - e_m\right) - F \mid \tilde{I}\right] \geq 0, \text{ and}$$

$$(9.17) \qquad (1 - w)\,E\left(\tilde{u}\left(\tilde{x} + \tilde{e} - R\,\tilde{S}\right) \mid \tilde{I}\right) \geq -U.$$

The first term in the objective function is the future value of the firm, the second term is the transfer from the corporate managers to compensate for personal use of inside information, and the third term is the expected trading profit of owners trading as liquidity traders. Thus, all these factors are taken into account when the current shareholders determine s.

Condition (9.16) is the participation constraint of corporate managers. The first term is the profit from insider trading, the second term is the amount paid for the privilege of insider trading, and the last term is the cost of supplying effort. In this way, rational behavior means that corporate managers will only participate if they expect to profit from such behavior. Condition (9.17) is the participation constraint of pure liquidity traders. This condition turns out to be necessary to preclude destabilizing control strategies, and the maximum amount of money they are willing to pay for satisfying their liquidity needs is denoted U.

The optimal control policy s* is either an inner optimum or on one of the boundaries. After studying the problem numerically, the first order condition to (9.15) produces a minimum, implying that s* lies on one of the boundaries.

Lemma 6.10: *Suppose $U > U'$, then there exists an optimal control policy $s^* \in [s_{min}, s_{max}]$ determined by current shareholders such that their control problem given by (9.15) - (9.17) is maximized. The lower limit s_{min} is determined such that (9.17) holds with equality whereas the upper limit s_{max} is the largest s such that (9.16) holds with equality. If $U > U'' \geq U'$ (where U' and U'' are constants), then*

$$(9.18)\quad s^* = s_{min} = 1 + (M + 1)\sqrt{\frac{\Theta}{M\sigma\left[1 - \left[N(\Gamma+\varepsilon) + M(\Gamma+\eta)\alpha^2\right]\left(\frac{1 - w}{a(M + 1)U}\right)^2\sigma\right]}}.$$

<u>Proof</u>: See appendix E.

We see that current shareholder should increase the price of allowing insider trading if, for instance, the uncertainty about the managerial quality increases. This is because greater uncertainty about managerial quality leads to more effort generated information which may subsequently be used to generate more expected profit on insider trading.

Corollary 6.8: *If $U \rightarrow \infty$, then $s^* = 1 + (M + 1)(\Theta / M\sigma)^{1/2}$.*

Proof: This follows directly from (9.18). Q.E.D.

If the pure liquidity traders trade whatever the market conditions are, e* is to destabilize the market to earn unbounded profit. When $\Phi \to \infty$, the market is called unstable.

Corollary 6.9: *If $U > U``$, then*

$$\Phi = \frac{1}{M}\left[\frac{(M + 1)^2 U^2}{(1 - w)^2 \sigma} - \frac{N(\Gamma + \varepsilon) + M(\Gamma + \eta)\alpha^2}{a^2}\right], \tag{9.19}$$

where α is given by (3.7) and a is given by (4.15). The trading intensities are $B = \alpha\beta$, $b = a\beta$, and

$$\beta = \frac{(1 - w)\sigma}{(M + 1)aU}. \tag{9.20}$$

The price sensitivity is

$$\lambda = \frac{U}{(1 - w)\sigma}. \tag{9.21}$$

Proof: If $U > U``$, (9.17) holds and I insert (9.18) into (4.11), (4.14), and (4.16), and obtain equations (9.19) - (9.21). Q.E.D.

We observe that when the participation constraint of pure liquidity traders is binding, the variance of total effort does not depend on the uncertainty about the quality of corporate managers. Instead it depends on parameters such as w and U which determine the constraint (9.17).

Proposition 6.11: *Suppose $U > U``$, then*

$$(9.22) \qquad \frac{d\Phi}{da} > 0,\ \frac{d\Phi}{dw} > 0,\ \frac{d\Phi}{dU} > 0,\ \frac{d\Phi}{d\sigma} < 0,\ \textit{and}\ \frac{d\Phi}{d\left[\lambda^2 - \lim\limits_{s\to\infty}\lambda^2\right]} > 0.$$

Proof: This follows from differentiating (9.19) with respect to the relevant variables. Note that

$$(9.23) \qquad \Phi = \frac{\sigma(M+1)^2}{M}\left[\lambda^2 - \lim_{s\to\infty}\lambda^2\right],$$

where $\lim_{s\to\infty}\lambda$ is the price sensitivity in a corresponding security market with no effort generated information (see (9.14) or (2.3.8)). Q.E.D.

The variability of managerial effort increases when the component in the bid ask spread reflecting effort generated information increases. This is because the corporate managers have to generate more information for a given level of expected profit if the component in the spread reflecting effort generated information for some reason increases.

6.10 SHORT SUMMARY OF MAJOR CONCLUSIONS

I have found that there under certain conditions exists a production and exchange economy with insider trading as the mechanism promoting managerial effort. My findings show that compensation through insider trading motivates half of the corporate managers to supply an effort greater than expected whereas the other half is motivated to supply an effort less than expected. The average effort depends on the market's pre-trade expectation about effort which again depends on the public expectations about the ability of managers. A higher pre-trade expectation leads to a higher average effort, reflecting that the shareholders should set high standards for their managers. This symmetry in effort choices suggests that insider trading as an incentive mechanism is not very effective, and insider trading may very easily be dominated by other incentive mechanisms such as linear outcome-contingent schemes.

APPENDICES

This section contains the proofs of the lemmas which are not proved directly in the sections which they are presented.

Appendix A Proof of lemma 6.1

I start by deriving the trading strategy of the corporate insiders trading on both effort generated information and information about random business fluctuations. Secondly, I find the trading strategy of the market professionals trading solely on information about random business fluctuations simply by adjusting the corresponding trading strategy derived in the proof of lemma 2.1. Thirdly, the response of the price setting market makers is derived. Finally, the closed form solutions of the trading intensities and the price sensitivity given in lemma 6.1 are found.

A 1 The trading strategy of the corporate insiders

The portfolio-selection problem of insider m $\in$ {1, 2, ..., M} is given by (2.11). I insert the price function given by (A17) below and provide this equivalent problem.

$$\text{(A1)} \qquad \underset{\tilde{\Delta}_m}{\text{Max}}\ \tilde{\Delta}_m \, E\left[(\tilde{x} + \tilde{e}) - \left(E[\tilde{x} + \tilde{e} \mid I] + \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \tilde{\Delta}_m + \sum_{m=1}^{M-1}\tilde{\Delta}_m + \tilde{u}\right)\right) \mid \tilde{I}_m, I\right],$$

where I_m represents the manager's inside information and I represents public information (that is, I = {y*=y*, y•=y•, ...} and I_m = {y, Y}). The corporate manager observes the realizations of the public signals y* and y• and then forms a stochastic trading strategy which depends on private information represented by the signals y and Y (see figure 6.1 for the sequence of events). It is straightforward to come from (A1) to the following problem.

(A2) $$\underset{\tilde{\Delta}_m}{\text{Max}}\ \tilde{\Delta}_m \left\{\left(E\left[\tilde{x} + \tilde{e} \mid \tilde{I}_m, I\right] - E[\tilde{x} + \tilde{e} \mid I]\right) - \lambda\left(\tilde{\Delta}_m + E\left[\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m \mid \tilde{I}_m, I\right]\right)\right\}.$$

The first order condition is

(A3) $$\left(E\left[\tilde{x} + \tilde{e} \mid \tilde{I}_m, I\right] - E[\tilde{x} + \tilde{e} \mid I]\right) - \lambda\left(2\tilde{\Delta}_m + E\left[\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m \mid \tilde{I}_m, I\right]\right) = 0,$$

or

(A4) $$\tilde{\Delta}_m = \frac{1}{2\lambda}\left(E\left[\tilde{x} + \tilde{e} \mid \tilde{I}_m, I\right] - E[\tilde{x} + \tilde{e} \mid I]\right) - \frac{1}{2}E\left[\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m \mid \tilde{I}_m, I\right].$$

Note that the second order condition is $-2\lambda < 0$. This means that $\lambda > 0$ to obtain a viable equilibrium. The next step is to simplify the expectations. It is straightforward to show that

(A5) $$E\left[\tilde{x} + \tilde{e} \mid \tilde{I}_m, I\right] = E[\tilde{x} + \tilde{e} \mid I] + \frac{\operatorname{cov}\left(\tilde{x} + \tilde{e}, \tilde{Y} \mid \tilde{y}, I\right)}{\operatorname{var}\left(\tilde{Y} \mid \tilde{y}, I\right)}\left(\tilde{Y} - E\left[\tilde{Y} \mid \tilde{y}, I\right]\right)$$
$$+ \frac{\operatorname{cov}\left(\tilde{x} + \tilde{e}, \tilde{y} \mid \tilde{Y}, I\right)}{\operatorname{var}\left(\tilde{y} \mid \tilde{Y}, I\right)}\left(\tilde{y} - E\left[\tilde{y} \mid \tilde{Y}, I\right]\right), \text{ and}$$

(A6) $$E\left[\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m \mid \tilde{I}_m, I\right] = E\left[\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m \mid I\right] + \frac{\operatorname{cov}\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m, \tilde{Y} \mid \tilde{y}, I\right)}{\operatorname{var}\left(\tilde{Y} \mid \tilde{y}, I\right)}\left(\tilde{Y} - E\left[\tilde{Y} \mid \tilde{y}, I\right]\right)$$
$$+ \frac{\operatorname{cov}\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m, \tilde{y} \mid \tilde{Y}, I\right)}{\operatorname{var}\left(\tilde{y} \mid \tilde{Y}, I\right)}\left(\tilde{y} - E\left[\tilde{y} \mid \tilde{Y}, I\right]\right).$$

I insert (A5) and (A6) into (A4). The result is

$$\text{(A7)}\ \tilde{\Delta}_m = \frac{1}{2\lambda}\left(\begin{array}{l} \dfrac{\operatorname{cov}\left(\tilde{e} - \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m\right), \tilde{Y} \mid \tilde{y}, I\right)}{\operatorname{var}\left(\tilde{Y} \mid \tilde{y}, I\right)}\left(\tilde{Y} - E\left[\tilde{Y} \mid \tilde{y}, I\right]\right) \\ + \dfrac{\operatorname{cov}\left(\tilde{x} - \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m\right), \tilde{y} \mid \tilde{Y}, I\right)}{\operatorname{var}\left(\tilde{y} \mid \tilde{Y}, I\right)}\left(\tilde{y} - E\left[\tilde{y} \mid \tilde{Y}, I\right]\right) \end{array}\right) - \frac{1}{2} E\left[\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m \mid I\right].$$

The corporate manager is rational and therefore foresee the structure of the market professionals' trading strategies given by (3.1). This means that

$$\text{(A8)} \qquad E\left[\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m \mid I\right] = 0,$$

$$\text{(A9)} \qquad \operatorname{cov}\left(\tilde{x} - \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m\right), \tilde{y} \mid \tilde{Y}, I\right) = \Gamma - \left(N\beta\,\Gamma + (M-1)\,B\,(\Gamma + \eta)\right)\lambda, \text{ and}$$

$$\text{(A10)} \qquad \operatorname{cov}\left(\tilde{e} - \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M-1}\tilde{\Delta}_m\right), \tilde{Y} \mid \tilde{y}, I\right) = \Phi - (M-1)\,B\,(\Phi + \iota)\,\lambda.$$

Now I insert (A8), (A9), and (A10) into (A7) and yield

$$\text{(A11)} \qquad \tilde{\Delta}_m = \frac{1}{2\lambda}\left(\begin{array}{c} \dfrac{\Phi - (M-1)\,b\,(\Phi + \iota)\,\lambda}{(\Phi + \iota)}\left(\tilde{Y} - E\left[\tilde{Y} \mid \tilde{y}, I\right]\right) + \\ \dfrac{\Gamma - \left(N\beta\,\Gamma + (M-1)\,B\,(\Gamma + \eta)\right)\lambda}{(\Gamma + \eta)}\left(\tilde{y} - E\left[\tilde{y} \mid \tilde{Y}, I\right]\right) \end{array}\right),$$

or the trading strategy is as it is given by (3.2). The trading intensities are

$$\text{(A12)} \qquad b = \frac{\Phi}{(M+1)\,(\Phi + \iota)\,\lambda}, \text{ and}$$

$$\text{(A13)} \qquad B = \frac{(1 - N\beta\lambda)\,\Gamma}{(M+1)\,(\Gamma + \eta)\,\lambda}.$$

A 2 Trading strategy of market professionals

I find the trading strategy of the market professionals simply by extending (2.3.1) to the case where $\Phi > 0$. But since the professionals do not observe effort generated information, the new trading strategy equals (3.1) where the trading intensity is (see (2.A29))

(A14) $$\beta = \frac{(1 - MB\lambda)\Gamma}{[(N + 1)\Gamma + 2\varepsilon]\lambda}.$$

Note, however, that the price sensitivity (and thereby the trading intensity) will be different here than in chapter 2.

A 3 The price response of market makers

The Q price setting market makers are forced by the competition in the dealership market to set the bid ask spread so low that they make zero expected profit. In this way, the equilibrium condition in the dealership market is

(A15) $$E\left[- \tilde{z}\left((\tilde{x} + \tilde{e}) - R\tilde{S}\right) \mid \tilde{z}, I\right] = 0,$$

where the conditioned z is the information obtained from observing the order flow time t. This suggests that the market makers face an adverse selection or a differentiation problem to the pricing of securities. This price function follows directly from (A15).

(A16) $$\tilde{S} = \frac{1}{R} E[\tilde{x} + \tilde{e} \mid \tilde{z}, I],$$

or

(A17) $$\tilde{S} = \frac{1}{R} \left\{ E[\tilde{x} + \tilde{e} \mid I] + \lambda \tilde{z} \right\},$$

where the sensitivity of the market price toward changes in the equilibrium order flow is

(A18) $$\lambda = \frac{\operatorname{cov}(\tilde{x} + \tilde{e}, \tilde{z} \mid I)}{\operatorname{var}(\tilde{z} \mid I)}.$$

The equilibrium order flow is pooled so the price setting market makers cannot distinguish orders coming from uninformed liquidity traders from orders coming from informed speculators. Thus,

(A19) $$\tilde{z} = \sum_{n=1}^{N} \tilde{\theta}_n + \sum_{m=1}^{M} \tilde{\Delta}_m + \tilde{u}.$$

I insert (3.1) and (3.2) and get

(A20) $$\begin{aligned} \tilde{z} = {} & M b \tilde{e} + (N\beta + MB)\tilde{x} + \beta \sum_{n=1}^{N} \tilde{e}_n + MB\tilde{h} + Mb\tilde{i} + \tilde{u} \\ & - Mb\,E[\tilde{e} \mid \tilde{y}^* = y^*] - (N\beta + MB)\,E[\tilde{x} \mid \tilde{y}^* = y^*]. \end{aligned}$$

The next step is to insert this into (A18). The result is

(A21) $$\lambda = \frac{(N\beta + MB)\Gamma + Mb\Phi}{M^2 b^2 (\Phi + \iota) + (N\beta + MB)^2 \Gamma + N\beta^2 \varepsilon + M^2 B^2 \eta + \sigma}.$$

A 4 Closed form solutions

I insert (A14) into (A13) and get

(A22) $$B = \frac{\alpha \Gamma}{[N\Gamma + (M + 1)(\Gamma + \eta)\alpha]\lambda}.$$

where α is given by (3.7). I insert this into (A14) and the result is

$$\text{(A23)} \qquad \beta = \frac{\Gamma}{\left[N\Gamma + (M + 1)(\Gamma + \eta)\,\alpha\right]\lambda}.$$

The nest step is to substitute (A22) and (A23) into (A21) which yields (3.9) after some straightforward but tedious algebraic simplifications. I then substitute (3.9) into (A12), (A22), and (A23) to get (3.3), (3.4), and (3.5). This completes the proof of lemma 6.1.

Appendix B Proof of lemma 6.2

If $L = A$, the effort-selection problem of manager $m \in \{1, 2, ..., M\}$ is at time t_{-4} given by (4.1). I insert the trading strategy given by (3.2) and the price function given by (3.8). The result is

$$\text{(B1)} \qquad \underset{\tilde{e}_m}{\mathrm{Max}}\; E\Big[b\left(\tilde{Y} - E\big[\tilde{Y} \mid \tilde{y}_\bullet = y_\bullet\big]\right)\left((\tilde{x} + \tilde{e}) - \{E[\tilde{x} + \tilde{e} \mid I] + \lambda \tilde{z}\}\right) \mid \tilde{e}_m, \tilde{I}\Big] +$$
$$E\Big[B\left(\tilde{y} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right)\left((\tilde{x} + \tilde{e}) - \{E[\tilde{x} + \tilde{e} \mid I] + \lambda \tilde{z}\}\right) \mid \tilde{e}_m, \tilde{I}\Big] - E\Big[\tilde{C}(\tilde{e}_m) \mid \tilde{e}_m, \tilde{c}, \tilde{I}\Big],$$

where z is given by (A20). The manager's expected profit is the sum of the expected profit from trading on effort generated information and privileged information correlated with business fluctuations minus the expected costs of effort.

I find that (see (4.A6))

$$\text{(B2)} \quad E\Big[B\left(\tilde{y} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right)\left((\tilde{x} + \tilde{e}) - \{E[\tilde{x} + \tilde{e} \mid I] + \lambda \tilde{z}\}\right) \mid \tilde{e}_m, \tilde{I}\Big] = \mathrm{cov}\left(B\,\tilde{y},\, (\tilde{x} + \tilde{e}) - \lambda \tilde{z} \mid \tilde{e}_m, \tilde{I}\right)$$
$$= B\left[\Gamma - \lambda\left((N\beta + MB)\Gamma + MB\eta\right)\right] = \frac{\alpha^2(\Gamma + \eta)\Gamma^2}{\left[N\Gamma + (M + 1)(\Gamma + \eta)\,\alpha\right]^2 \lambda},$$

where I have inserted (A22) and (A23). Because the corporate manager's two sources of information are uncorrelated, the expected profit from trading on random fluctuations does not depend on the manager's choice of effort.

Effort generated information represented by the signal Y gives the corporate manager the following expected profit.

(B3)
$$E\left[b\left(\tilde{Y} - E\left[\tilde{Y} \mid \tilde{y}_\bullet = y_\bullet\right]\right)\left((\tilde{x} + \tilde{e}) - \{E[\tilde{x} + \tilde{e} \mid I] + \lambda \tilde{z}\}\right) \mid \tilde{e}_m, \tilde{I}\right] =$$
$$E\left[\begin{array}{c} b\left(\tilde{e}_m + \sum_{m=1}^{M-1}\tilde{e}_m + \tilde{i} - E\left[\tilde{e} + \tilde{i} \mid \tilde{y}_\bullet = y_\bullet\right]\right) \cdot \\ \left(\left(\tilde{x} + \tilde{e}_m + \sum_{m=1}^{M-1}\tilde{e}_m\right) - \left\{E[\tilde{x} + \tilde{e} \mid I] + \lambda\left[\begin{array}{c} b\left(\tilde{e}_m + \sum_{m=1}^{M-1}\tilde{e}_m + \tilde{i} - E\left[\tilde{e} + \tilde{i} \mid \tilde{y}_\bullet = y_\bullet\right]\right) + \\ (M-1)\, b\left(\tilde{e} + \tilde{i} - E\left[\tilde{e} + \tilde{i} \mid \tilde{y}_\bullet = y_\bullet\right]\right) + \tilde{z}^{`} \end{array}\right]\right\}\right) \mid \tilde{e}_m, \tilde{I} \end{array}\right],$$

where z\` is the remaining order flow. This simplifies to

(B4)
$$E\left[b\left(\tilde{Y} - E\left[\tilde{Y} \mid \tilde{y}_\bullet = y_\bullet\right]\right)\left((\tilde{x} + \tilde{e}) - \{E[\tilde{x} + \tilde{e} \mid I] + \lambda \tilde{z}\}\right) \mid \tilde{e}_m, \tilde{I}\right] =$$
$$b\left(\begin{array}{c} \tilde{e}_m + E\left[\sum_{m=1}^{M-1}\tilde{e}_m \mid \tilde{e}_m, \tilde{I}\right] \\ - E\left[\tilde{e} \mid \tilde{I}\right] \end{array}\right)\left(\left(\begin{array}{c} \tilde{e}_m + \\ E\left[\sum_{m=1}^{M-1}\tilde{e}_m \mid \tilde{e}_m, \tilde{I}\right] \end{array}\right) - E\left[\tilde{e} \mid \tilde{I}\right] - \lambda\left[\begin{array}{c} b\left(\tilde{e}_m + E\left[\sum_{m=1}^{M-1}\tilde{e}_m \mid \tilde{e}_m, \tilde{I}\right] - E\left[\tilde{e} \mid \tilde{I}\right]\right) \\ + (M-1)\, b\left(E\left[\tilde{e} \mid \tilde{e}_m, \tilde{I}\right] - E\left[\tilde{e} \mid \tilde{I}\right]\right) \end{array}\right]\right),$$

where

(B5)
$$E\left[\sum_{m=1}^{M-1}\tilde{e}_m \mid \tilde{e}_m, \tilde{I}\right] = E\left[\sum_{m=1}^{M-1}\tilde{e}_m \mid \tilde{I}\right] + \frac{\operatorname{cov}\left(\sum_{m=1}^{M-1}\tilde{e}_m, \tilde{e}_m \mid \tilde{I}\right)}{\operatorname{var}\left(\tilde{e}_m \mid \tilde{I}\right)}\left(\tilde{e}_m - E\left[\tilde{e}_m \mid \tilde{I}\right]\right), \text{ and}$$

(B6)
$$E\left[\tilde{e} \mid \tilde{e}_m, \tilde{I}\right] = E\left[\tilde{e} \mid \tilde{I}\right] + \frac{\operatorname{cov}\left(\tilde{e}, \tilde{e}_m \mid \tilde{I}\right)}{\operatorname{var}\left(\tilde{e}_m \mid \tilde{I}\right)}\left(\tilde{e}_m - E\left[\tilde{e}_m \mid \tilde{I}\right]\right).$$

The next step is to insert (B5) and (B6) into (B4). The result is

(B7)
$$E\left[b\left(\tilde{Y} - E\left[\tilde{Y} \mid \tilde{y}_\bullet = y_\bullet\right]\right)\left((\tilde{x} + \tilde{e}) - \left\{E[\tilde{x} + \tilde{e} \mid I] + \lambda \tilde{z}\right\}\right) \mid \tilde{e}_m, \tilde{I}\right] =$$
$$b\left(\tilde{e}_m - E\left[\tilde{e}_m \mid \tilde{I}\right]\right)^2 \left(1 + \frac{\operatorname{cov}\left(\sum_{m=1}^{M-1} \tilde{e}_m, \tilde{e}_m \mid \tilde{I}\right)}{\operatorname{var}\left(\tilde{e}_m \mid \tilde{I}\right)}\right)^2 (1 - M b \lambda).$$

I then differentiate with respect to e_m and get

$$\text{(B8)}\ \frac{E\left[\,\cdot \mid \tilde{e}_m, \tilde{I}\right]}{d\,\tilde{e}_m} = 2\,b\left(1 + \frac{\operatorname{cov}\left(\sum_{m=1}^{M-1} \tilde{e}_m, \tilde{e}_m \mid \tilde{I}\right)}{\operatorname{var}\left(\tilde{e}_m \mid \tilde{I}\right)}\right)^2 \left(1 - \frac{d\,E\left[\tilde{e}_m \mid \tilde{I}\right]}{d\,\tilde{e}_m}\right)(1 - M b \lambda)\left(\tilde{e}_m - E\left[\tilde{e}_m \mid \tilde{I}\right]\right).$$

This implies that the corporate manager is assumed to recognize that his choice of individual effort affects the transaction price, the effort choice of other managers, and the expectation about effort among outsiders (see comments in appendix C).

I insert (A12) and end up with

$$\text{(B9)}\ \frac{E\left[\,\cdot \mid \tilde{e}_m, \tilde{I}\right]}{d\,\tilde{e}_m} = 2\left(1 + \frac{\operatorname{cov}\left(\sum_{m=1}^{M-1} \tilde{e}_m, \tilde{e}_m \mid \tilde{I}\right)}{\operatorname{var}\left(\tilde{e}_m \mid \tilde{I}\right)}\right)^2 \left(1 - \frac{d\,E\left[\tilde{e}_m \mid \tilde{I}\right]}{d\,\tilde{e}_m}\right)\frac{\Phi\,(\Phi + (M+1)\,\iota)}{(M+1)^2\,(\Phi + \iota)^2\,\lambda}\left(\tilde{e}_m - E\left[\tilde{e}_m \mid \tilde{I}\right]\right).$$

The manager's choice of effort is determined by the first order condition of the manager's effort-selection problem given by (B1). By using (B9), I get (4.2). The second order condition is given by (4.3) where $d^2 E[e_m \mid I] / d\,e_m^2 = 0$ because $E[e_m \mid I]$ obviously have to be a linear function in e_m. This completes the proof of lemma 6.2.

Appendix C Proof of lemma 6.3

If the cost function is given by (4.4), its expectation given available information at time t_4 (when the effort decision is made) is

(C1) $$E\left[\tilde{C}(\tilde{e}_m) \mid \tilde{e}_m, \tilde{c}, \tilde{I}\right] = E\left[f(\tilde{e}_m - e_m)^2 + 2\tilde{c}(\tilde{e}_m - e_m) \mid \tilde{e}_m, \tilde{c}, \tilde{I}\right] + F,$$

where conditioned c and e_m mean that the corporate manager knows his quality or type and thereby his own individual effort, but to outsiders such as price setting market makers c and e_m are stochastic variables. This implies that

(C2) $$E\left[\tilde{C}(\tilde{e}_m) \mid \tilde{e}_m, \tilde{c}, \tilde{I}\right] = f(\tilde{e}_m - e_m)^2 + 2\tilde{c}(\tilde{e}_m - e_m) + F.$$

I differentiate with respect to e_m and obtain

(C3) $$\frac{d\, E\left[\tilde{C}(\tilde{e}_m) \mid \tilde{e}_m, \tilde{c}, \tilde{I}\right]}{d\,\tilde{e}_m} = 2\left\{f(\tilde{e}_m - e_m) + \tilde{c}\right\}\left(1 - \frac{d\, E\left[\tilde{e}_m \mid \tilde{I}\right]}{d\,\tilde{e}_m}\right).$$

I insert this into (4.2) and solve for e_m where $E[E[e_m \mid I]] = e_m$ because of rational expectations. The double expectation is used because e_m is determined at time t_{-4} just before the signal y• is revealed to the public. The result is

(C4) $$\tilde{e}_m = e_m - \frac{(M+1)^2(\Phi+\iota)^2\lambda}{\left\{f(M+1)^2(\Phi+\iota)^2\lambda - \left(1 + \frac{\operatorname{cov}\left(\sum_{m=1}^{M-1}\tilde{e}_m, \tilde{e}_m \mid \tilde{I}\right)}{\operatorname{var}(\tilde{e}_m \mid \tilde{I})}\right)^2 \Phi(\Phi + (M+1)\iota)\right\}}\tilde{c}.$$

I assume that there is only one type of managers in each firm. This assumption makes the optimal choice of effort consistent with the information structure in trading equilibrium (see (2.6)) and to the chosen equilibrium concept (see appendix B). The total effort is therefore known to each manager at time t_{-4} because $e = M\, e_m$. Given this assumption, the individual effort given by (4.7) follows from (C4). Outsiders do not observe e_m and individual effort is therefore a normally distributed variable with expectation e_m and the variance given by (4.8). This completes the proof of lemma 6.3.

Appendix D Proof of lemma 6.9

The expected profits of the participants are summarized in table 6.3. Stable owners have two sources of income which are their initial position and their share of the transfer from the managers for the privilege of trading on inside information. Thus,

$$\text{(D1)} \qquad E\left[(1 - v)\sum_{o=1}^{O} \tilde{\pi}_o^O \mid \tilde{I}\right] = (1 - v)\left\{E\left[\tilde{x} + \tilde{e} \mid \tilde{I}\right] + \frac{Ms}{(M + 1)^2 \lambda}(\Gamma + \Phi)\right\}.$$

I insert M^2 var(e_m | I) where var(e_m | I) is given by (4.8), and yield (9.3). The liquidity trading owners have also two sources of income, but they have to pay a cost for changing their initial position at time t. This means that

$$\text{(D2)} \qquad E\left[v\sum_{o=1}^{O} \tilde{\pi}_o^O + w\sum_{d=0}^{D+1} \tilde{\pi}_d^{D+1} \mid \tilde{I}\right] = v\left\{E\left[\tilde{x} + \tilde{e} \mid \tilde{I}\right] + \frac{Ms}{(M + 1)^2 \lambda}(\Gamma + \Phi)\right\} - w\lambda\sigma.$$

I substitute in for Φ and yield (9.4). The pure liquidity traders have no initial position. But they have to pay a cost for taking long or short positions in security k at time t, and (9.5) follows straightforwardly. The market professionals expect to profit from their trading because they observe a private signal correlated with the random business fluctuations which influence the future value of security k. I find that (see (4.A10))

$$\text{(D3)} \qquad E\left[\sum_{n=1}^{N} \tilde{\pi}_n^N \mid \tilde{I}\right] = N\beta\left\{\Gamma - \lambda\left[(N\beta + MB)\Gamma + \beta\varepsilon\right]\right\}.$$

I insert (3.5) and (A23). After straightforward simplifications, the result is given by (9.6). The expected profit of corporate insiders comes from inside information, but is reduced by the transfer to the owners and the cost of making effort.

$$\text{(D4)}\quad E\left[\sum_{m=1}^{M}\tilde{\pi}_m^M \mid \tilde{I}\right] = M\left[B\left\{\Gamma - \lambda\begin{bmatrix}(N\beta + MB)\Gamma \\ + MB\eta\end{bmatrix}\right\} - \frac{s\Gamma}{(M+1)^2\lambda}\right] - \frac{M(1-s)\Phi}{(M+1)^2\lambda} - \begin{bmatrix}F - \\ 2\sqrt{\Phi\Theta}\end{bmatrix}.$$

I insert (3.5), (A23), and (4.8) where $\iota = 0$ and f is given by (4.9). The result given by (9.7) appears after straightforward calculations. The market makers are assumed to earn zero expected profit which gives (9.8) directly. This completes the proof of lemma 6.9.

Appendix E Proof of lemma 6.10

First, consider the problem without the participation constraints

$$\text{(E1)}\qquad \underset{s > 1+(M+1)\sqrt{\frac{\Theta}{M\sigma}}}{\text{Max}} E\left[\tilde{x} + \tilde{e} \mid \tilde{I}\right] + \frac{Ms}{(M+1)^2\lambda}\left(\Gamma + \left[\frac{(M+1)^2\lambda}{M(s-1)}\right]^2\Theta\right) - w\lambda\sigma.$$

When s approaches its lower limit or infinity, the value of the objective function approaches infinity (as is the case with (9.10) when v = 1). This means that the first order condition produces at least one *minimum* on the range $(1 + (M+1)(\Theta / M\sigma)^{1/2}, \infty)$, and if there exists a local maximum, a larger value can be found near one of the limits.

If we add (9.17), then $s^* \geq s_{min}$ where s_{min} is unique and given by (9.18). I find (9.18) by solving (9.17) holding with equality. Finally, if we add (9.16), $s^* < \infty$ because otherwise (9.16) does not hold. This implies that $s^* \in [s_{min}, s_{max} < \infty]$ where s_{max} is the largest s where (9.16) holds. According to (9.13), s_{max} must exist. Now define $U^{*} \in \mathbf{R}_+$ such that when $U \geq U^{*}$, $s_{min} \leq s_{max}$ and when $U < U^{*}$, $s_{min} > s_{max}$. If the latter is the case, the equilibrium does not exist because the two participation constraints cannot be satisfied simultaneously. If (9.16) holds with equality only when $s = s_{max}$, then the constraint holds on the whole interval from s_{min} to s_{max}. This seems always to be the case when I analyze the problem numerically, but I have not been able (or rather bothered) to prove it in general. If U is large, $s^* = s_{min}$ because s_{min} is near the lower limit $1 + (M+1)(\Theta / M\sigma)^{1/2}$ and the maximum is on the limit set by (9.17). Let U^{**} be the lowest U where $s^* = s_{min}$. This completes the proof of lemma 6.10.

Appendix F Example

The following numerical values are used in figures 6.2 - 6.3 to illustrate the equilibrium in the production and exchange economy given by lemma 6.3 - 6.4.

TABLE 6.4:			Numerical values					
Γ	=	2	N	=	2	F	=	0
Θ	=	2	M	=	10	e_m	=	1
ε	=	2	σ	=	1	$E[\tilde{c} \mid I]$	=	0
η	=	1	s	=	7.5			

With this set of numerical parameters, s has to be greater than 5.919 to obtain a viable insider trading equilibrium.

REFERENCES

Ausubel, L. M., 1990, "Insider Trading in a Rational Expectations Economy," American Economic Review, 1022 - 1041.

Dennert, J., 1990, "Insider Trading and the Allocation of Risks," Discussion Paper #77, London School of Economics.

Dye, R., 1984, "Insider Trading and Incentives," Journal of Business, 295 - 313.

Easterbrook, F. H., 1985, "Insider Trading as an Agency Problem," Chapter 4 in J. Pratt and R. Zeckhauser, "Principals and Agents: The Structure of Business," Harvard Business School Press, 81 - 100.

Fishman, M. J., and K. M. Hagerty, 1992, "Insider Trading and the Efficiency of Stock Prices," Rand Journal of Economics, 106 - 122.

Holmström, B., 1979, "Moral Hazard and Observability," Bell Journal of Economics, 74 - 91.

Holmström, B., 1982, "Managerial Incentive Problems: A Dynamic Perspective," In "Essays in Economics and Management in Honor of Lars Wahlbeck," Swedish School of Economics.

Leftwich, R. W., and R. E. Verrecchia, 1983, "Insider Trading and Managers` Choice Among Risky Projects," Working Paper #63, Center of Research in Security Prices, Graduate School of Business, University of Chicago.

Leland, H. E., 1992, "Insider Trading: Should it be Prohibited?" Journal of Political Economy, 859 - 887.

Manne, H. G., 1966, "Insider Trading and the Stock Market," Free-Press.

Manove, M., 1989, "The Harm from Insider Trading and Informed Speculation," Quarterly Journal of Economics, 823 - 845.

Shavell, S., 1979, "Risk Sharing and Incentives in the Principal and Agent Relationship," Bell Journal of Economics, 55 - 73.

SYMBOL GLOSSARY

OF PART III

(see also the symbol glossary of part II)

a	205, 212
α	164, 205
$\bar{A}$	222
A	163
b	204
$\mathbf{b}$	222
β	163, 179, 204, 211, 232
B	164, 204
$\mathbf{B}$	164
c	167, 208
$c, c`$	167, 176
$c^{\bullet}, c^{\bullet`}, c^{\bullet\bullet}$	185
$C(\,)$	167, 173, 208
d	202
d_t	168
δ	199
D	202
$D(\,)$	185
Δ_m	163, 201, 204
e, e^*	163, 166, 170, 199
e^c	190
e_m	166, 206, 207
$e^c{}_m$	190
$\mathbf{e}_m$	208
$e`_m$	167, 168, 207
$e^*{}_m$	167, 169, 207, 209, 210
$e^{**}{}_m$	168
$e^{\bullet}{}_m$	168, 169
e_n	201
ε	201
f, F	208, 209
ϕ	199
Φ	200, 210, 232
g	200
$\gamma, \gamma^*, \gamma^{**}, \gamma`$	184, 185, 186, 200
$\Gamma, \Gamma_{MIN}, \Gamma_{MAX}, \Gamma^*$	164, 200, 219
h	200
$\eta, \eta^*, \eta^{**}, \eta`$	184, 185, 186, 200
i	200
ι	200
I, I_m	201
j	200

PART IV

OTHER EXTENSIONS

CHAPTER 7

INSIDER TRADING IN AN IMPERFECTLY COMPETITIVE MARKET WITH RISK AVERSE AGENTS

First draft: November 1990,
Current revision: December 1992.

ABSTRACT

A change in the security market law from allowing to banning insider trading is shown to affect the expected profit and the risk exposure of all the traders. Take, for instance, the uninformed and semi-rational liquidity traders whose welfare depends on their expected trading costs and the risk of trading at a price different from the future value of the security. The expected trading cost is determined by the equilibrium bid ask spread and their trading volume, where the spread depends on adverse selection and risk compensation. As in previous chapters, the adverse selection component is caused by the price differentiation problem of market makers. It may either increase or decrease with the supply of corporate insiders, depending on the change in the insiders' market power. However, the risk compensation component is caused by the aversion of market makers towards variations in the price deviation. It is shown to be reduced by insider trading. This is because corporate insiders improve the informativeness of the pooled order flow, and thereby reduce the risk of taking the opposite position vis-à-vis the traders. Insider trading has also a desirable effect on the liquidity traders' risk premium because corporate insiders tend to bring the transaction price nearer to its underlying value based on privileged information. This suggests that the welfare of liquidity traders are improved by intensive insider trading.

7.1 INTRODUCTION

I extend the risk neutral and imperfectly competitive market characterized by lemma 2.1 to a corresponding economy where all the participants are risk averse. This means that the difference between this and the previous approach is that now the participants demand risk premia to compensate for the risk of losing money on their uncovered positions.

Market makers

I assume that there are price taking behavior in the dealership market, resulting in a sort of Bertrand price competition among the limited number of price setting market makers (see, e.g., Fudenberg and Tirole (1991), page 12). This means that the market makers are satisfied with earning zero expected utility which in turn indicates that their expected welfare is not affected by changes in the activities of corporate insiders. However, risk averse market makers expect to earn a positive expected profit to compensate for the risk of always taking the opposite position vis-à-vis the various demanders of immediacy. This trading risk is caused by variations in the difference between the transaction price and its future value, and compensation takes place through the equilibrium bid ask spread. In this way, there are two components in the quoted bid ask spread, one reflecting the adverse selection problem and one reflecting the risk compensation.

Liquidity traders

The risk adjusted trading cost of semi-rational noise or liquidity traders equals the expected trading cost plus an appropriate risk premium. The expected trading cost depends on the equilibrium bid ask spread and the trading volume, whereas the risk premium depends on risk aversion and the trading risk. This implies that the risk adjusted trading cost is a tax on liquidity traders that subsidizes the acquisition of private information and its subsequent dissemination through the price system (see, e.g., Kyle (1989b), page 159). The importance of the bid ask spread when evaluating the desirability of insider trading is recognized by, e.g., King and Röell (1988), pages 169 - 170.

If the supply of corporate insiders increases, the adverse selection problem faced by the price setting market makers depends on whether the entering new insiders have additional non-public information or they just compete with existing insiders. But an additional supply of corporate insiders reduces the risk compensation of market makers because informed trading reduces the trading risk. The reason is that insider trading reveals information through the net order flow which in turn reduces the uncertainty of the future value of the security and thereby the uncertainty associated with current trading. These effects suggest that insider trading tends to reduce the bid ask spread and consequently the expected trading cost of liquidity traders. Nevertheless, if the supply of insiders is relatively small (e.g., shifting from zero to one), the spread and the expected trading cost may increase due to the arrival of new non-public information.

Risk averse liquidity traders also take into account their risk exposure. It depends on their risk aversion and their trading risk where the risk in turn depends on their position in the securities market and the variance of the difference between the current price and its future value. If insider trading expands, there are two effects on the variance of the pricing error. Insider trading reveals information about the future value of the security, reducing the fundamental uncertainty, and drives the current price nearer to its underlying fundamental, reducing the possibilities that the price at which the liquidity traders trade are influenced by uncertainty generated by noise. This indicates that an increase in the supply of corporate insiders has a desirable effect on the risk exposure of liquidity traders.

I have argued that insider trading tends to decrease the expected trading cost and the trading risk of liquidity traders. The weight of these two effects, working in the same direction, depends on the risk aversion. If, for instance, the liquidity traders are relatively risk averse, the effect on their trading risk is important for the net effect on their risk adjusted trading cost. In this way, relatively risk averse discretionary liquidity traders want to trade in markets, securities, and periods where the risk of trading is low. This suggests that viable equilibria are to some extent dispersed and not concentrated, because the trading risk makes it desirable to trade together with informed traders such as corporate insiders and avoid trading together with too many noise traders. Noise traders create noise trader risk which increases the trading risk.

A major problem with liquidity traders is that the size of their trades are given as noise determined outside the equilibrium, and the only remaining decision is for the discretionary liquidity traders to decide where and when to execute their orders. If the trading cost of fully rational noise traders increases due to informed trading which erodes market liquidity, their trading would, as suggested by Kyle (1989, page 159), be reduced as part of the equilibrium. This is exactly what happens to the endogenously determined trading by the rational hedgers in Spiegel and Subrahmanyam (1992). The reason is reduced risk sharing possibilities due to revelation of superior information.

Corporate insiders

The risk adjusted profit of the corporate insiders equals the expected profit from insider trading minus an appropriate risk premium. The expected profit depends on the covariance between their trading strategy and the pricing error, whereas the appropriate risk premium depends on their risk aversion and the risk associated with insider trading.

If the supply of perfectly camouflaged and illegally trading insiders increases, the covariance between their trading strategy and the pricing error decreases. This is because of the reduction in the pricing error due to the information revealed to the price setting market makers through the influence of corporate insiders on the net order flow. Hence, competition among the corporate insiders decreases the expected profit generated by trading on inside information. Risk averse insiders take also the risk of trading into account, and if their supply increases, their risk exposure is reduced because of the reduction in the pricing error due to information leakages to the price setting market makers.

I have identified two effects on the risk adjusted profit of corporate insiders and argued that they are working in opposite directions. The net effect is influenced by their risk aversion, but even if the insiders are relatively risk averse, the effect on expected profit dominates. This suggests that corporate insiders, who are able to trade illegally without being discovered and punished, prefer insider trading prohibited and enforced. However, this does not necessarily imply that all insiders prefer a ban on insider trading because if some of them are prevented from trading by the surveillance of the stock market regulators, they do not expect to earn any supernormal profit at all.

Market professionals

The risk adjusted profit of quasi-insiders such as the privately informed market professionals equals the expected profit minus an appropriate risk premium. The expected profit depends on the covariance between their trading strategy and the pricing error, while the risk premium depends on the professionals' risk aversion and their trading risk.

The expected profit of market professionals tends to decrease with the number of corporate insiders when this number is small, but tends to increase for larger supply. The first effect is caused by an increase in the direct competition among the two types of superiorly informed speculators, whereas the second effect is caused through the reduction in the adverse selection problem of the price setting market makers (see section 4.3 for further elaborations). On the other hand, risk averse market professionals also take into account that insider trading tends to reduce their trading risk and therefore their risk exposure. This is because insider trading tends to reduce the variability of the pricing error.

In this way, there is a trade-off between the effect on expected profit and the effect on risk exposure. The importance of these two effects on the risk adjusted profit of market professionals is determined by their risk aversion. For instance, if the professionals are relatively risk averse, the positive effect on risk exposure tends to be important, and reduces the usually negative effect on expected profit which in turn leads to an increase in the expected risk adjusted profit. Nevertheless, the market professionals tend to prefer insider trading outlawed and the law effectively enforced.

Notice that the quasi-insiders are not "arbitrageurs" so they must not be confused with such traders studied in most previous research on insider trading regulations (see, e.g., Leland (1992), page 863). The trading strategies of arbitrageurs are generally determined on the basis of public information generated by correctly anticipating or observing the equilibrium price. In my model, there is no arbitrage because there is nothing to gain by following trading strategies based on any public information or the current transaction price. This is because the transaction price is set by competitive market makers trading away all such gains in the dealership market.

On some of the other studies on insider trading

This chapter is closely related to the literature on risk averse and imperfectly competitive markets like Admati and Pfleiderer (1988a) and Subrahmanyam (1991). None of these articles, though, deal with insider trading regulations *per se*, but their financial market approach is in my view the best approach to analyze regulations on the use of various types of information. Their equilibrium restated in corollary 7.1 is a special cases of my equilibrium given by lemma 7.1.

In Admati and Pfleiderer (1988a) there are no market professionals only corporate insiders. The risk averse insiders observe a common signal, and submit orders, together with the orders from the liquidity traders, to the risk neutral and competitive market makers whose duty is to set the market clearing price. The linear and imperfectly competitive equilibrium has no closed form solution, but is characterized by a fifth-order equation. Their findings suggest that the total value of inside information may increase in the number of informed traders because of a better allocation of risk. However, the value of information to each trader tends to decrease because of increased competition. This indicates that banning insider trading increases the individual welfare of illegally trading insiders, but may reduce their total welfare. Admati and Pfleiderer also observe that if the number of speculators is small, the effect of risk sharing is stronger, while if the number of speculators is large, the competition effect is stronger. This indicates that there is a trade-off between coordination, i.e., less competition, and risk sharing when evaluating the desirability of prohibiting insider trading. These effects are, of course, present in my more general version of their trading model.

Subrahmanyam (1991) focuses on the trading cost of uninformed liquidity traders in a trading model identical to the one in Admati and Pfleiderer (1988a), except that he extends the analysis to the case of risk averse market makers. The properties of the equilibrium such as liquidity and price efficiency are analyzed, and the most interesting welfare result is that when the information acquisition is endogenous, Subrahmanyam finds that the trading cost of liquidity traders is not always monotonically declining in the amount of noise trading. This suggests that if liquidity traders are able to time their trades, they may prefer to trade in a dispersed fashion as opposed to their behavior in the concentrated trading equilibrium of Admati and Pfleiderer (1988b). Nevertheless, as long as there is at least one corporate insider, it is optimal to trade together with as many insiders as possible. This implies that uninformed and risk neutral liquidity traders may prefer insider trading allowed.

My study confirms the skepticism towards insider trading found in the previous literature focusing directly on whether such trading should be prohibited or not. Leland (1992), for instance, concludes on page 862 that if the investment is inflexible to changes in the current stock price, the net welfare of the participants tends to be lower when insider trading is permitted where, according to his table on page 877, corporate insider gains but arbitrageurs and liquidity traders lose. The main difference between his approach and mine is that I recognize competition among the corporate insiders.

The rest of the chapter proceeds as follows. The next section is used to discuss the additional assumptions needed to extend from the risk neutral market characterized by lemma 2.1 to lemma 7.1 characterizing the corresponding risk averse market. Unfortunately, the risk averse equilibrium has no closed form solution so I have to analyze it numerically. I analyze the properties of lemma 7.1 in sections four, five, and six, focusing on the effects on the trading intensities, the price sensitivity, and the market efficiency respectively. The effects caused by insider trading regulations on the welfare of corporate insiders, quasi-insiders like market professionals, and uninformed liquidity traders are analyzed in sections seven and eight. Finally, section nine concludes the chapter. The numerical values used in the example and the formal proofs of some of the lemmas are found in the appendices.

7.2 ASSUMPTIONS

I draw on the multi-period, multi-security market specified in sections 2.2 - 2.3 and extend it to a corresponding economy where the corporate insiders, the market professionals, the liquidity traders, and the price setting market makers are all risk averse.

In this setting, rational behavior implies that market professional $n \in \{1, 2, ..., N\}$ maximizes expected utility given diverse information represented by the signal y_n. I assume that the professional's utility function is

$$U\left(\tilde{\theta}_n\left(\tilde{x} - R\tilde{S}\right)\right) = -\exp\left\{-\rho_N\,\tilde{\theta}_n\left(\tilde{x} - R\tilde{S}\right)\right\}, \tag{2.1}$$

where θ_n (x - R S) is the professional's final wealth and ρ_N is the common risk aversion coefficient of all the market professionals trading in security $k \in \{1, 2, ..., K\}$ at the auction at time $t \in \{0, 1, ..., T_k\text{-}1\}$. In this way, the utility function is exponential which means that $U' > 0$, $U'' < 0$, and $-U''/U' = \rho_N$ (i.e., U is of the CARA-class).

The professional's portfolio-selection problem consists of finding the trading strategy θ_n which maximizes the certainty equivalent or the risk adjusted profit, and it becomes quite easy because of the exponential utility function and normally distributed variables:

$$\underset{\tilde{\theta}_n}{\mathrm{Max}}\; E\left[\tilde{\theta}_n\left(\tilde{x} - R\tilde{S}\right) \mid \tilde{y}_n, \tilde{y}^* = y^*\right] - \frac{\rho_N}{2}\,\mathrm{var}\left(\tilde{\theta}_n\left(\tilde{x} - R\tilde{S}\right) \mid \tilde{y}_n, \tilde{y}^* = y^*\right), \tag{2.2}$$

where θ_n is the optimal trading strategy which at time t_{-1} is submitted, together with the orders from the other security traders, to the price setting market makers. Notice that the trading strategy of market professionals is independent of their initial wealth (here normalized to zero) because of exponential utility function (and normally distributed variables).

In the same way, corporate insider $m \in \{1, 2, ..., M\}$ maximizes his or her risk adjusted profit given the information represented by their common signal y. Again the utility function is assumed to be exponential, leading to the following portfolio-selection problem.

$$\underset{\tilde{\Delta}_m}{\mathrm{Max}}\; E\left[\tilde{\Delta}_m\left(\tilde{x} - R\tilde{S}\right) \mid \tilde{y}, \tilde{y}^* = y^*\right] - \frac{\rho_M}{2}\,\mathrm{var}\left(\tilde{\Delta}_m\left(\tilde{x} - R\tilde{S}\right) \mid \tilde{y}, \tilde{y}^* = y^*\right), \tag{2.3}$$

where ρ_M is the common risk aversion coefficient of all corporate insiders, and Δ_m is the insider's trading strategy which at time t_{-1} is submitted, together with orders from the other traders, to the price setting market makers.

The liquidity traders have not acquired private information correlated with the future value of the firm and are assumed to determine the size of their trades outside the model. Nevertheless, the D discretionary liquidity traders are risk averse and evaluate the risk adjusted cost of trading a random amount of shares before they choose strategically in which securities and periods to trade. This suggests that discretionary liquidity traders maximize the certainty equivalent given public information and the information generated by their own trades by choosing the securities and periods to trade. Hence, the liquidity traders are semi-rational. The risk adjusted trading profit of liquidity trader $d \in \{1, 2, ..., D\}$ equals

$$\text{(2.4)} \qquad E\left[\tilde{u}_d \left(\tilde{x} - R\,\tilde{S}\right) \mid \tilde{u}_d,\, \tilde{y}^* = y^*\right] - \frac{\rho_D}{2} \operatorname{var}\left(\tilde{u}_d \left(\tilde{x} - R\,\tilde{S}\right) \mid \tilde{u}_d,\, \tilde{y}^* = y^*\right),$$

where u_d is the discretionary liquidity trader's planned trade and ρ_D is the common risk aversion coefficient of all liquidity traders. After calculating the certainty equivalent trading costs for every k and t and given their intervals of discretion, the liquidity traders choose in which securities and periods to trade, and submit their random orders to the dealers. In models where risk averse traders have initial positions in the risky assets, there might exist a Nash equilibrium without noise as in Bossaerts and Hughson (1991) and in Spiegel and Subrahmanyam (1992). In the next chapter, a similar setting is rigged by replacing the irrational liquidity traders with rational and wealth maximizing hedgers.

As in Subrahmanyam (1991), the market makers are also assumed to be risk averse, and by assuming competitive behavior in the dealership market, the dealers or market makers are forced to set the transaction price to make zero expected utility given the information content generated by observing the net equilibrium order flow. Thus,

$$\text{(2.5)} \qquad E\left[\tilde{z}_q \left(R\,S - \tilde{x}\right) \mid \tilde{z},\, \tilde{y}^* = y^*\right] - \frac{\rho_Q}{2} \operatorname{var}\left(\tilde{z}_q \left(R\,S - \tilde{x}\right) \mid \tilde{z},\, \tilde{y}^* = y^*\right) = 0,$$

where $z_q = z / Q$ is the part of the order flow handled by market maker $q \in \{1, 2, ..., Q\}$, z is the pooled order flow from the demanders of immediacy, and ρ_Q is the common risk aversion coefficient of all the market makers. It is straightforward by using the rules of conditional expectation and conditional variance of normally distributed random variables to show that the equilibrium price

$$\text{(2.6)} \qquad \tilde{S} = \frac{1}{R} \left\{E[\tilde{x} \mid \tilde{y}^* = y^*] + \lambda\,\tilde{z}\right\},$$

where the price sensitivity (see also Subrahmanyam (1991), page 430 for an approach where the market makers are risk averse)

$$(2.7) \qquad \lambda = \frac{\mathrm{cov}(\tilde{x}, \tilde{z} \mid \tilde{y}^* = y^*)}{\mathrm{var}(\tilde{z} \mid \tilde{y}^* = y^*)} + \frac{\rho_Q}{2\,Q}\,\mathrm{var}(\tilde{x} \mid \tilde{z}, \tilde{y}^* = y^*).$$

The first term is a component reflecting the price differentiation problem or the adverse selection problem to the pricing of security k (see (2.2.19)), while the second term is a component compensating the market makers for the risk of always having to take the opposite position vis-à-vis the various types of traders.

This implies that the price process of security k from t=0 to $t=T_k$, denoted S_{kt}, is no longer a strict martingale, but a so called supermartingale which is adjusted for the fact that the superior information is short lived (that is, useful for only one period; see section 2.2). A supermartingale S_{kt} is defined by $E[x_{k,t+1} \mid z_{kt}] \leq S_{kt}$; see, e.g., Billingsley (1986), pages 484 - 485, and, as in Kyle (1989a), prices over-react relative to their unbiased level. Finally, notice that this approach is consistent with general pricing theory under homogenous beliefs. Roughly speaking, the price of a claim $x_{k,t+1}$ is $S_{kt} = E[x_{k,t+1}\, U'(x_{t+1})] = E[x_{k,t+1}]\, E[U'(x_{t+1})] + \mathrm{cov}(x_{k,t+1}, U'(x_{t+1}))$ where x_{t+1} is the value of the market portfolio at time t+1 and $U'(x_{t+1})$ is its marginal utility. If I normalize $E[U'(x_{t+1})]$ to unity, we see directly that the price equals the expectation plus a risk premium; see, e.g., Duffie (1992), pages 3 - 13 for further elaborations.

7.3 EQUILIBRIUM

I define a Nash-type equilibrium in this setting. An imperfectly competitive equilibrium is (1) a price system $\{S_{kt}\}$ and (2) a specification of the trading strategies of the privately informed traders $\{\theta_{nkt}, \Delta_{mkt}\}$ such that (i) the informed speculators maximize expected utility and (ii) the prices are set by competitive market makers making zero expected utility.

Lemma 7.1: *A pooling of orders equilibrium in security $k \in \{1, 2, ..., K\}$ at the (call) auction at time $t \in \{0, 1, ..., T_k - 1\}$ is denoted $[(\theta_{nkt}, \Delta_{mkt}, u_{dkt}); S_{kt}]$. The trading strategies of market professionals and* *corporate insiders are*

$$\tilde{\theta}_n = \beta\left(\tilde{y}_n - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \text{ and} \tag{3.1}$$

$$\tilde{\Delta}_m = B\left(\tilde{y} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \tag{3.2}$$

respectively. The trading intensities are characterized by

$$\beta = \frac{[1 - MB\lambda]\Gamma}{[(N + 1)\Gamma + 2\varepsilon]\lambda + \rho_N \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}_n, \tilde{y}^* = y^*\right)(\Gamma + \varepsilon)}, \text{ and} \tag{3.3}$$

$$B = \frac{[1 - N\beta\lambda]\Gamma}{(\Gamma + \eta)\left\{(M + 1)\lambda + \rho_M \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}, \tilde{y}^* = y^*\right)\right\}}, \tag{3.4}$$

in which

$$\operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}_n, \tilde{y}^* = y^*\right) = \frac{\Gamma\varepsilon}{\Gamma + \varepsilon}\left[\frac{1 -}{\lambda((N - 1)\beta + MB)}\right]^2 + \lambda^2\left[\begin{matrix}(N - 1)\beta^2\varepsilon + \\ M^2B^2\eta + \sigma\end{matrix}\right], \text{ and} \tag{3.5}$$

$$\operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}, \tilde{y}^* = y^*\right) = \frac{\Gamma\eta}{\Gamma + \eta}[1 - N\beta\lambda]^2 + \lambda^2\left[N\beta^2\varepsilon + \sigma\right]. \tag{3.6}$$

The transaction price of security k at time t is

$$\tilde{S} = \frac{1}{R}\left\{E[\tilde{x} \mid \tilde{y}^* = y^*] + \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m + \tilde{u}\right)\right\}, \tag{3.7}$$

where the Q risk averse and competitive market makers set the price sensitivity

$$\lambda = as + rc, \tag{3.8}$$

where

(3.9) $$\text{as} = \frac{(N\beta + MB)\Gamma}{(N\beta + MB)^2\,\Gamma + N\beta^2\,\varepsilon + M^2 B^2\,\eta + \sigma}, \textit{ and}$$

(3.10) $$\text{rc} = \frac{\rho_Q\left(N\beta^2\,\varepsilon + M^2 B^2\,\eta + \sigma\right)\Gamma}{2\,Q\left[(N\beta + MB)^2\,\Gamma + N\beta^2\,\varepsilon + M^2 B^2\,\eta + \sigma\right]}.$$

If $L = B$, then μ replaces M.

Proof: See appendix A.

This lemma extends lemma 2.1 to a corresponding equilibrium where both the traders and the price setting market makers are risk averse. It is straightforward to alter the equilibrium to the case where both types of informed speculators observe either common or diverse information or to the case where the corporate insiders observe diverse information and the market professionals observe common information; see section 2.2 for details on the information structures.

Special cases

Some of the earlier studies on asymmetric information in financial markets appear as special cases of lemma 7.1.

Corollary 7.1: *Suppose $N = 0$ and $\rho_Q = 0$, then*

(3.11) $$B = \frac{\Gamma}{(\Gamma + \eta)(M + 1)\lambda + \rho_M\left\{\Gamma\eta + \lambda^2(\Gamma + \eta)\sigma\right\}}, \textit{ and}$$

(3.12) $$\lambda = \frac{MB\Gamma}{M^2 B^2(\Gamma + \eta) + \sigma}.$$

Proof: This follows from (3.4) and (3.8). Q.E.D

The equilibrium in Admati and Pfleiderer (1988a) given by their equations (3) and (4), and lemma 1 and 2 in Subrahmanyam (1991) is a special case of corollary 7.1 in which Γ is normalized to unity. Nevertheless, Subrahmanyam extends in his lemma 4 to the case where there are risk averse market makers ($\rho_Q > 0$, but there is still only one type of superiorly informed speculators). If I insert (3.11) into (3.12), the price sensitivity is determined by a fifth order equation which has a unique positive real root (see proposition 1 in Subrahmanyam (1991)).

Corollary 7.2: *Suppose $M = 0$ and $Q = 1$, then*

$$(3.13) \quad \beta = \frac{\Gamma}{\begin{bmatrix}(N+1)\Gamma \\ +\, 2\varepsilon\end{bmatrix}\lambda + \rho_N \left\{ \varepsilon \begin{bmatrix} 1 - \\ \lambda(N-1)\beta \end{bmatrix}^2 \Gamma + \lambda^2 \begin{bmatrix}(N-1)\beta^2\varepsilon \\ +\, \sigma\end{bmatrix}(\Gamma + \varepsilon)\right\}}, \text{ and}$$

$$(3.14) \quad \lambda = \frac{\left[N\beta + \frac{\rho_Q}{2}\left(N\beta^2\varepsilon + \sigma\right)\right]\Gamma}{N\beta^2(N\Gamma + \varepsilon) + \sigma}.$$

Proof: This follows from (3.3) and (3.8). Q.E.D

If the semi-rational liquidity traders are replaced by rational, maximizing hedgers (see section 8.1 for an approach where the total hedging demand, denoted $H\,v^2\,\omega$, replaces the total liquidity demand represented by σ), this corollary equals the equilibrium conditions for the most general model discussed by Spiegel and Subrahmanyam (1992) in their appendix B, pages 327 - 328.

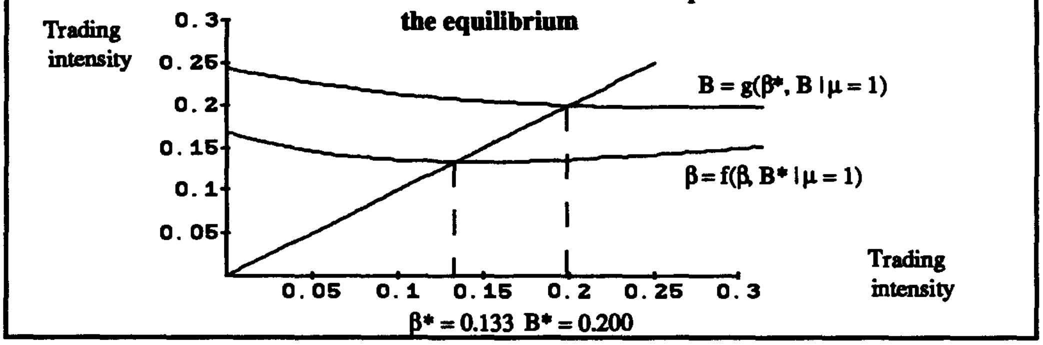
Extensions

In the next chapter, I extend the analysis to a stock market equilibrium which has lemma 7.1 as a special case. There the market makers realize their market power as in Kyle (1984), and the liquidity traders are replaced by hedgers as in Spiegel and Subrahmanyam (1992). Then I use the equilibrium to evaluate the effects of insider trading regulations on the welfare of informed speculators, uninformed hedgers, and individuals supplying intermediacy (including arbitrageurs competing with the market makers) much in the same way as in this chapter.

On the existence of an equilibrium - the fixed point

I insert (3.8) into (3.3) and (3.4). The results are $\beta = f(\beta, B)$ and $B = g(\beta, B)$ which determine the equilibrium as the related fixed points $\beta^* = f(\beta^*, B^*)$ and $B^* = g(\beta^*, B^*)$. Figure 7.1 illustrates how the fixed points are determined using the numerical values given in table 7.4.

FIGURE 7.1 On the existence and uniqueness of the equilibrium



The related fixed points are calculated by a converging sequence $\{(\beta_i, B_i); i = 0, 1, 2, ...\}$. The initial values (β_0, B_0) are chosen, for instance, to be the trading intensities in a corresponding security market with risk neutral agents. Then I use (3.3) and (3.4) to calculate the next values $\beta_1 = f(\beta_0, B_0)$ and $B_1 = g(\beta_0, B_0)$ and so on until the sequence converges at β^* and B^*.

***Proposition 7.1:** There exists a unique, linear equilibrium $[(\beta^*, B^*); \lambda^*]$ given by (3.1) - (3.10).*

<u>Proof</u>: To prove the uniqueness, I apply the contraction mapping principle (see, e.g., Duffie (1988), page 191). It holds as the mapping, given by the right hand side of (3.3) and (3.4), are strict contractions from a complete metric space $[0, \infty)$ into itself. Obviously, $[0, \infty)$ is a metric space ($d(a, b) = 0 \iff a = b$, $d(a, b) = d(b, a)$, and

$d(a, c) \leq d(a, b) + d(b, c)$ where $a, b, c \in [0, \infty)$ and d is a positive, real-valued function on $[0, \infty) \times [0, \infty)$ called a metric) and it is complete because every Cauchy sequence converges (that is, a sequence $\{s_i\}$ is Cauchy if there exists an integer J so that $d(s_i, s_j) \leq e \in (0, \infty)$ for all $i, j \in \{1, 2, ...\}$ larger than J, and a sequence $\{s_i\}$ converges if there exists $s \in [0, \infty)$ such that $d(s_i, s) \rightarrow 0$). Equation (3.3) is a strict contraction because $| f(\beta_j, B^*) - f(\beta_i, B^*) | < c \, | \beta_j - \beta_i |$ where $c \in (0, 1)$ and $i < j$. This means that $| \partial f(\beta, B^*) / \partial \beta | < c$ for all $\beta \in [0, \infty)$ and $c \in (0, 1)$ which by inspection is obviously the case. In the same way, equation (3.4) is a strict contraction, implying that the related problem given by (3.3) and (3.4) together is a strict contraction. Q.E.D.

Nonetheless, I have no closed form solution. I therefore choose to analyze the equilibrium numerically. This is done by presenting an example based on the numerical values given in table 7.4. This example forms the basis for all the illustrations throughout the chapter.

7.4 TRADING INTENSITIES

The trading strategies of the market professionals and the corporate insiders are according to (3.1) and (3.2) linear responses to superior information where the trading intensities given by (3.3) and (3.4) measure how responsive these speculators are to informational changes. The trading intensities depend on factors such as the risk exposure.

Proposition 7.2: *Suppose the stock market is given by (3.1) - (3.10), then*

(4.1) $$\frac{\partial \beta}{\partial \rho_N} < 0 \text{ and } \frac{\partial B}{\partial \rho_M} < 0.$$

Proof: This follows easily by differentiating (3.3) and (3.4) partially with respect to the relevant variables. Q.E.D.

Other things equal, the trading intensities of market professionals and corporate insiders are higher, the lower risk aversion they have. This means that risk averse speculators trade less than corresponding risk neutral speculators because they take into account the various risks associated with security trading and therefore find it optimal to reduce their trading.

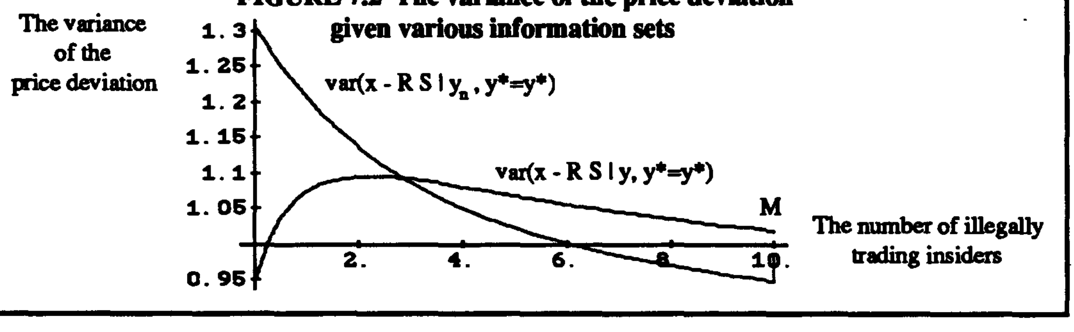
Proposition 7.3: *Suppose the stock market is given by (3.1) - (3.10), then*

$$(4.2) \qquad \frac{\partial \beta}{\partial \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}_n, \tilde{y}^* = y^*\right)} < 0 \text{ and } \frac{\partial B}{\partial \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}, \tilde{y}^* = y^*\right)} < 0.$$

Proof: This follows by differentiating (3.3) and (3.4) with respect to the relevant variables holding other variables constant. Q.E.D.

The trading intensities of superiorly informed speculators are higher, the lower risk of trading at a price different from the future value of the security. This suggests that risk averse speculators reduce their trading if, for instance, there is much uncertainty about the demand from the noise or liquidity traders. On the other hand, informed trading tend to reduce the trading risk because it brings the price nearer to its underlying fundamental value. Figure 7.2 illustrates how the conditional variances given by (3.5) and (3.6) depend on the number of illegally trading insiders.

FIGURE 7.2 The variance of the price deviation given various information sets



In this example, the variance of the price deviation given privately acquired information is a monotonically decreasing function (which decreases from 1.306 when $\mu = 0$ to 0.949 when $\mu = 10$), whereas the variance given inside information is a unimodal function (which increases from 0.944 when $\mu = 0$ to 1.096 when $\mu = 2$, and then falls to 1.018 when $\mu = 10$).

If the supply of corporate insiders increases, the trading risk of market professionals decreases. This is because insider trading reveals information to the market makers, brings the transaction price nearer to its underlying fundamental, and thereby reduces the volatility of the pricing error. According to (3.6), the trading risk of corporate insiders does not depend directly on their own supply because each insider knows his own demand and the demand from the other corporate insiders. This suggests that their risk effect is indirect and it depends mainly on how the market makers react to the larger number of corporate insiders in the order flow. This accounts for the fact that their execution risk may increase in the insiders own supply due to the increase in the equilibrium bid ask spread for small supplies of corporate insiders; see section 7.5 for an analysis of the price response of market makers.

On the motives for trading

The superiorly informed speculators trade because they have better (or more precise) information than the market.

Proposition 7.4: *Suppose the stock market equilibrium is given by (3.1) - (3.10), then*

(4.3) $$\lim_{\varepsilon \to \infty} \beta(\varepsilon) = 0 \textit{ and } \lim_{\eta \to \infty} B(\eta) = 0.$$

Proof: These limits follow from (3.3) and (3.4) holding other variables constant. Q.E.D.

This means that in this model there is no trading caused by risk sharing only trading motivated by superior information and exogenously given liquidity events. This is because initially, before trading takes place, there are no risky positions. However, if there were an effect caused by the initial wealth, rational shareholders in general would like to trade in order to share the risk even if they have no private information. As originally shown by Hirshleifer (1971), there would in such a market also be an effect caused by an early resolution of uncertainty on the risk sharing possibilities. These issues are discussed in the next chapter.

Market professionals

I have also examined numerically the trading behavior of the market professionals when the supply of corporate insiders changes.

***Proposition** 7.5: The trading intensity of market professionals <u>tends</u> to be a unimodal function in the supply of corporate insiders μ:*

$$\text{Sgn}\left(\frac{d\beta}{d\mu}\right) = -\,\text{Sgn}\left(\mu_\beta - \mu\right) \textit{ where } \lim_{\mu\to 0}\beta(\mu) \geq \lim_{\mu\to\infty}\beta(\mu) \geq 0, \tag{4.4}$$

where μ_β, among other things, is a function of $\rho = (\rho_N, \rho_M, \rho_Q)$. If $\rho = (0, 0, 0)$ and $\eta = 0$, then $\mu_\beta \to \infty$ and $\beta(\mu)$ is a monotonically decreasing function (see (3.2.4) for a proof).

These tendencies are established after systematical, numerical analyses with the values given in table 7.4 as the base case. Technically, it is done by studying what happens $\beta(\mu)$ if the numerical values of all the exogenous parameters are changed systematically. Figure 7.3 illustrates what happens.

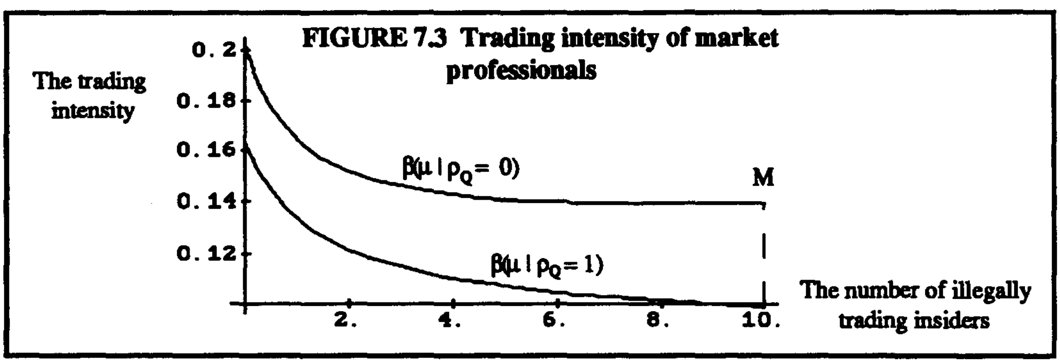


FIGURE 7.3 Trading intensity of market professionals

We observe that the trading intensities fall in the interval [0, 10], but when $\rho_Q = 0$, the trading intensity is really a unimodal function. This is because $\beta(\mu = 0 \mid \rho_Q = 0) = 0.203 > \beta(\mu \to \infty \mid \rho_Q = 0) = 0.183 > \beta^{\bullet}(\mu_\beta = 9 \mid \rho_Q = 0) = 0.139$ where $\bullet$ indicates the minimum. However, $\beta^{\bullet}(\mu = 0 \mid \rho_Q = 1) = 0.163 > \beta(\mu_\beta \to \infty \mid \rho_Q = 0) = 0.086$, suggesting that $\beta(\mu)$ is monotonically decreasing in μ. I conclude that the market professionals tend to trade more aggressively when L = **B** than when L = A.

Corporate insiders

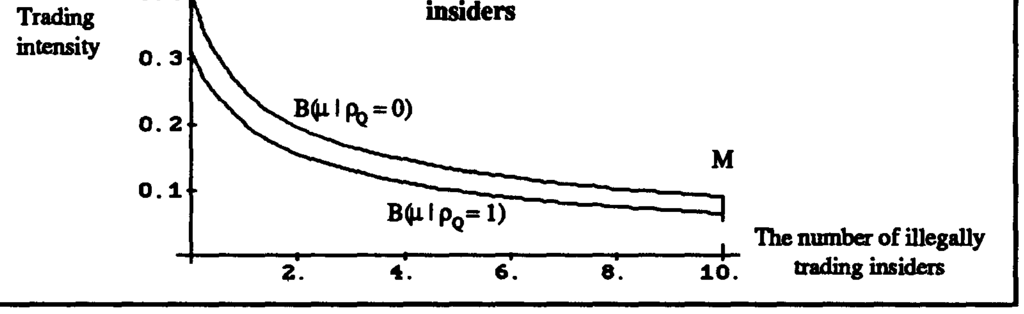
Risk averse insiders care about the risk of trading at a price which differs from the underlying value of the security. This trading risk increases, for instance, when uninformed traders intensify their trading because they may push the transaction price in the wrong direction so that the corporate insiders realize a loss (noise trader risk), or when the internal information becomes more noisy because the insider then face a greater risk of making a bad decision and thereby realize a loss (fundamental risk).

Proposition 7.6: *The trading intensity of corporate insiders* <u>*tends*</u> *to fall monotonically in their own supply* μ*:*

$$\text{(4.5)} \qquad \frac{dB}{d\mu} < 0 \text{ where } \lim_{\mu \to 0} B(\mu) > \lim_{\mu \to \infty} B(\mu) = 0.$$

Figure 7.4 gives an example.

FIGURE 7.4 Trading intensity of corporate insiders



We observe that $B \cdot (\mu = 0 \mid \rho_Q = 0) = 0.403 > B(\mu \to \infty \mid \rho_Q = 0) = 0$ and $B \cdot (\mu = 0 \mid \rho_Q = 1) = 0.312 > B(\mu \to \infty \mid \rho_Q = 1) = 0$. If the illegally trading insiders are perfectly camouflaged by (or as) outsiders, I conclude that corporate insiders have a desire to trade harder when L = **B** than when L = A. Nonetheless, M - μ insiders choose to follow the law.

7.5 PRICE SENSITIVITY

The equilibrium condition in the dealership market given by (2.5) expresses that even if they are limited in number, the price setting market makers behave competitively and therefore expect to earn no economic rents from their activity. Hence, the stock market exchange is taken to be a non-profit organization which sets the price sensitivity and thereby the equilibrium bid ask spread without exploiting its privilege as the only supplier of immediacy.

Proposition 7.7: *Suppose the stock market exchange is given by (3.1) - (3.10), then the equilibrium price sensitivity increases monotonically with its adverse selection component. Thus,*

(5.1)
$$\frac{\partial \lambda}{\partial \mathrm{as}} > 0,$$

where

(5.2)
$$\lambda \geq \lim_{\rho_Q \to 0} \lambda(\rho_Q) = \mathrm{as}.$$

<u>Proof</u>: The derivative given by (5.1) is obvious from (3.8). The limit follows directly from (3.9) - (3.10). Q.E.D.

If for some reason the adverse selection problem faced by the price setting market makers increases, the price sensitivity and thereby the equilibrium bid ask spread increases. According to (5.2), the market makers have to take into account the adverse selection problem to the pricing of securities. If the market makers are risk neutral, no risk compensation is needed.

Proposition 7.8: *Suppose the stock market equilibrium is given by (3.1) - (3.10), then the equilibrium price sensitivity increases monotonically with its risk compensation component. Thus,*

(5.3)
$$\frac{\partial \lambda}{\partial \mathrm{rc}} > 0,$$

where

(5.4)
$$\frac{\partial \mathrm{rc}}{\partial \mathrm{Q}} < 0, \ \frac{\partial \mathrm{rc}}{\partial \rho_{\mathrm{Q}}} > 0, \ \frac{\partial \mathrm{rc}}{\partial \Psi} < 0, \textit{ and}$$

(5.5)
$$\lim_{\substack{N \to 0,\, M \to 0, \\ \varepsilon \to \infty,\ \text{and/or}\ \eta \to \infty}} \mathrm{rc}(N, M, \varepsilon, \eta) \geq 0.$$

<u>Proof</u>: I differentiate (3.8) with respect to rc and obtain (5.3), and, according to (2.7), the risk compensation is

(5.6)
$$\mathrm{rc} = \frac{\rho_{\mathrm{Q}}}{2\,\mathrm{Q}\,\Psi},$$

where Ψ is the price informativeness given by (6.1). I differentiate (5.6) with respect to the relevant variables and obtain (5.4). The limit follows from (3.10). Q.E.D.

Risk averse market makers have to be compensated for the risk of always taking the opposite position vis-à-vis the demanders of immediacy, leading to a higher price sensitivity than is the case in a corresponding market with risk neutral pricing. This is consistent with the findings in the market microstructure literature, for instance, Ho and Stoll (1981). They model the dealer as a risk bearer who takes on unwanted inventory, and the cost of holding an inventory position is reflected in the bid ask spread. The more risk averse the dealer is, the wider is the spread, and hence the larger is the trading cost.

The risk bearing component in the equilibrium bid ask spread increases when the number of market makers, their risk tolerance, or the market efficiency decreases. In this way, if the security price is a good estimate of the underlying value, the market makers face less risk of loosing money. They therefore lower the risk bearing component in the equilibrium bid ask spread. The same happens if they increase in number as their risk bearing capacity gives a better risk sharing. When $Q \to \infty$, the risk sharing is complete and the market makers do not need to be compensated for the execution risk because of a complete diversification of the order flow on the continuum of dealers. In this respect, the market makers form a syndicate to share the risk of holding inventory; see Wilson (1968).

Finally, notice that the price sensitivity is positive even when there are no informed trading. The reason is that risk averse market makers have to be compensated for the risk of trading together with the noise or liquidity traders.

Proposition 7.9: *Insider trading <u>tends</u> to increase the price informativeness and thereby to reduce the risk compensation component in the bid ask spread:*

$$\frac{\partial\, \mathrm{rc}}{\partial \mu} = \frac{\partial\, \mathrm{rc}}{\partial \Psi} \frac{\partial \Psi}{\partial \mu} < 0. \tag{5.7}$$

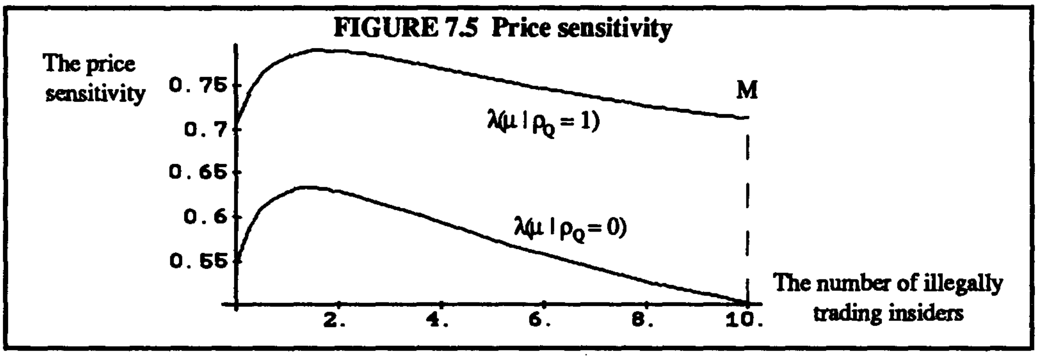
This suggests that insider trading may reduce the bid ask spread, but the spread also contains the adverse selection component.

Proposition 7.10: *The price sensitivity <u>tends</u> to be a unimodal function in the supply of corporate insiders μ:*

$$\mathrm{Sgn}\left(\frac{\mathrm{d}\lambda}{\mathrm{d}\mu}\right) = \mathrm{Sgn}(\mu_\lambda - \mu) \textit{ where } \lim_{\mu\to 0} \lambda(\mu) > \lim_{\mu\to\infty} \lambda(\mu) > 0, \tag{5.8}$$

where μ_λ, among other things, is a function of $\rho = (\rho_N, \rho_N, \rho_Q)$.

Figure 7.5 illustrates.



I find that $\lambda \bullet(\mu_\lambda = 1.5 \mid \rho_Q = 0) = 0.632 > \lambda(\mu = 0 \mid \rho_Q = 0) = 0.543 > \lambda(\mu \to \infty \mid \rho_Q = 0) = 0.200$ and $\lambda \bullet(\mu_\lambda = 1.5 \mid \rho_Q = 1) = 0.789 > \lambda(\mu = 0 \mid \rho_Q = 1) = 0.704 > \lambda(\mu \to \infty \mid \rho_Q = 1) = 0.595$. Hence, the unimodality of the price sensitivity and the bid ask spread observed in the risk neutral case carry over to the risk averse case, suggesting that the bid ask spread may be less when there are several insiders in the market than when there are none.

7.6 MARKET EFFICIENCY

The informativeness of the securities market is its ability to communicate information through the price system. Public information is always reflected in the price due to the construction of the equilibrium with price taking behavior in the dealership market. In addition, some of the private information held by the informed speculators is also reflected in the price system because informed traders reveal information through their orders.

Lemma 7.2: *The price informativeness is*

$$\Psi(M) = \frac{1}{\Gamma} + \frac{(N\beta + MB)^2}{N\beta^2 \varepsilon + M^2 B^2 \eta + \sigma}. \tag{6.1}$$

If $L = B$, then M is replaced by μ.

<u>Proof</u>: The price efficiency is measured by the parameter $\Psi = 1 / \mathrm{var}(x \mid S, y^{*}=y^{*})$, and (6.1) follows by straightforward calculations. Q.E.D.

The first term is the precision of the public signal, and the second term is the additional precision caused by privileged information revealed by the transaction price.

***Proposition 7.11:** Suppose the stock market equilibrium is given by (3.1) - (3.10), then*

$$(6.2)\ \frac{\partial\Psi}{\partial\Gamma} < 0,\ \frac{\partial\Psi}{\partial N} > 0,\ \frac{\partial\Psi}{\partial M} > 0,\ \frac{\partial\Psi}{\partial\varepsilon} < 0,\ \frac{\partial\Psi}{\partial\eta} < 0,\ \frac{\partial\Psi}{\partial\sigma} < 0,\ \frac{\partial\Psi}{\partial\beta} > 0,\ \textit{and}\ \frac{\partial\Psi}{\partial B} > 0.$$

Proof: This follows from differentiating (6.1) with respect to the relevant variables holding other variables constant. Q.E.D.

In this way, the price informativeness tends to increase with the amount of informed trading and decrease with noise.

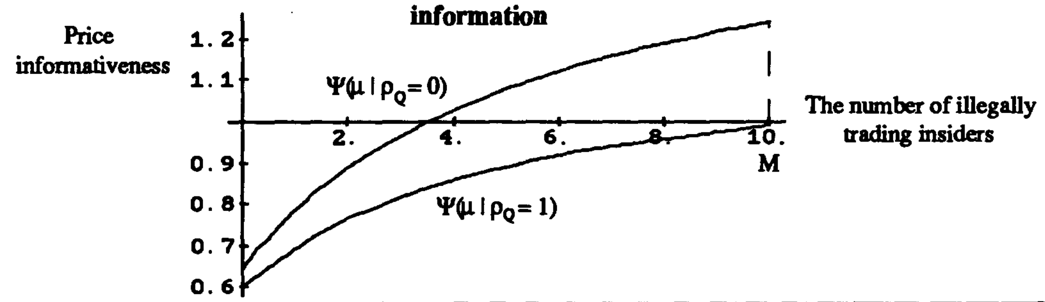
For instance, if the unexpected trades by noise or liquidity traders, represented by σ, increase exogenously, there is a tendency of declining price efficiency. This is because the superiorly informed speculators scale up their trades less than proportionally due to their risk aversion. Note also that increased risk aversion decreases the market efficiency; see Subrahmanyam (1991) proposition 2 for a similar result.

***Proposition 7.12:** The price informativeness tends to increase monotonically in the supply of corporate insiders:*

$$(6.3)\qquad \frac{d\Psi}{d\mu} > 0\ \textit{where}\ \lim_{\mu\to 0}\Psi(\mu) < \lim_{\mu\to\infty}\Psi(\mu) < \infty.$$

Figure 7.6 gives an example.

FIGURE 7.6 The market's ability to reflect information



I find that $\Psi(\mu = 0 \mid \rho_Q = 0) = 0.641 < \Psi\bullet(\mu \to \infty \mid \rho_Q = 0) = 1.618$ and $\Psi(\mu = 0 \mid \rho_Q = 1) = 0.596 < \Psi\bullet(\mu \to \infty \mid \rho_Q = 1) = 1.180$. The price efficiency is reduced if L changes from **A** to **B**.

7.7 WELFARE EFFECTS

The welfare of the demanders as well as the suppliers of immediacy is measured by their expected risk adjusted profit which equals the expected profit minus an appropriate risk premium.

Market makers

I assume that the market makers are compensated for the risk of taking the opposite position vis-à-vis the demanders of immediacy, but they earn zero expected utility given the information inferred from the equilibrium order flow.

***Lemma 7.3:** The pre-trade value of market making is*

$$\text{(7.1)} \qquad Ce_q = \frac{1}{2\rho_Q}\log\left(\left(1 + \rho_Q \operatorname{cov}\left(\tilde{z}_q, R\tilde{S} - \tilde{x} \mid \tilde{y}^* = y^*\right)\right)^2 - \rho_Q^2\left[\operatorname{var}\left(\tilde{z}_q \mid \tilde{y}^* = y^*\right) \cdot \operatorname{var}\left(R\tilde{S} - \tilde{x} \mid \tilde{y}^* = y^*\right)\right]\right) = 0,$$

where $z_q = z / Q$,

$$(7.2)\qquad \operatorname{cov}\left(\tilde{z}_q, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right) = \frac{1}{Q}\left(\lambda\begin{pmatrix}(N\beta + MB)^2\Gamma + \\ N\beta^2\varepsilon + M^2B^2\eta + \sigma\end{pmatrix} - (N\beta + MB)\Gamma\right),$$

$$(7.3)\qquad \operatorname{var}\left(\tilde{z}_q \mid \tilde{y}^* = y^*\right) = \frac{1}{Q^2}\left((N\beta + MB)^2\Gamma + N\beta^2\varepsilon + M^2B^2\eta + \sigma\right), \text{ and}$$

$$(7.4)\qquad \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right) = \Gamma\left[1 - \lambda(N\beta + MB)\right]^2 + \lambda^2\left[N\beta^2\varepsilon + M^2B^2\eta + \sigma\right].$$

Proof: See appendix B.

The value of market making is driven to zero because of the equilibrium condition in the dealership market given by (2.5). This means that the price setting market makers act competitively although they are limited in number. On the other hand, the market makers in the next chapter act strategically by increasing the price sensitivity beyond the competitive one given by (3.8).

Proposition 7.13: *Suppose the stock market equilibrium is given by (3.1) - (3.10), then the risk adjusted value of market making has these two limits as a function of the risk aversion coefficient:*

$$(7.5)\qquad \lim_{\rho_Q \to \infty} Ce_q(\rho_Q) = 0 \text{ and}$$

$$\lim_{\rho_Q \to 0} Ce_q(\rho_Q) = \operatorname{cov}\left(\tilde{z}_q, R\tilde{S} - \tilde{x} \mid \tilde{y}^* = y^*\right) = E\left[\tilde{z}_q\left(R\tilde{S} - \tilde{x}\right) \mid \tilde{y}^* = y^*\right] = 0.$$

Proof: First, notice that because of (2.5), $Ce_q = 0$ for all parameter values. Therefore the value of market making must also be zero when $\rho_Q \to \infty$ or $\rho_Q = 0$. Then I apply L' Hôpital's rule (see, e.g., Chiang (1984), page 429):

$$(7.6)\qquad \lim_{\rho \to 0}\frac{\log\left[(1 + \rho c)^2 - \rho^2 v\right]}{2\rho} = \lim_{\rho \to 0}\frac{\dfrac{d\log\left[(1 + \rho c)^2 - \rho^2 v\right]}{d\rho}}{\dfrac{d[2\rho]}{d\rho}} = \lim_{\rho \to 0}\frac{(1 + \rho c)c - \rho v}{(1 + \rho c)^2 - \rho^2 v} = c,$$

where c and v are two constants and ρ is the risk aversion coefficient. In this way, the proposed limit cov(z_q, R S - x | y*=y*) follows directly from this use of L' Hôpital's rule. Q.E.D.

When the market makers are risk neutral, the value of market making is expected profit. If $\rho_Q > 0$, the expected profit is positive but equals the risk premium.

Liquidity traders

Trading by noise traders is motivated by random liquidity events, suggesting that the u_d is given outside the equilibrium. Nevertheless, some of the noise traders are able within certain limits to decide when and where to trade.

Lemma 7.4: *There exists a $\rho_D < \rho_D$` such that the risk adjusted value of following a random trading strategy is*

(7.7) $$Ce_d(M) = \frac{1}{2\,\rho_D} \log\Big(\big(1 - \rho_D\,\lambda\,\sigma_d\big)^2 - \rho_D^2\,\sigma_d\,\mathrm{var}\big(\tilde{x} - R\,\tilde{S} \mid \tilde{y}^* = y^*\big)\Big),$$

where the total amount of liquidity trading $\sigma = \Sigma\,\sigma_d$ and the variance of the pricing error conditioned on public information is given by (7.4).

Proof: The given restriction on the risk aversion coefficient is caused by the condition that $(1 - r_D\,c)^2 - r^2_D\,v > 0$ in order that $\log((1 - r_D\,c)^2 - r^2_D\,v)$ is to exist. I solve the second order equation and obtain the upper limit $\rho_D` = (c / (c^2 - v)) + ((c^2 / (c^2 - v)^2) - (1 / (c^2 - v)))^{1/2}$. The rest of the proof follows directly from appendix B. Q.E.D.

If, for instance, $Ce_{dkt} > Ce_{dk,t+1}$, then liquidity trader d $\in$ {1, 2, ..., D} should choose to trade in period t rather than in period t+1.

Proposition 7.14: *Suppose the stock market equilibrium is given by (3.1) - (3.10), then there exists a set of parameters where in some regions*

$$(7.8) \qquad \frac{\partial \, Ce_d}{\partial \rho_D} < 0, \; \frac{\partial \, Ce_d}{\partial \sigma_d} < 0, \; \frac{\partial \, Ce_d}{\partial \lambda} < 0, \textit{ and } \frac{\partial \, Ce_d}{\partial \, var\left(\tilde{x} - R\,\tilde{S} \mid \tilde{y}^* = y^*\right)} < 0,$$

where

$$(7.9) \qquad \lim_{\rho_D \to \rho_D^{`} < \infty} Ce_d(\rho_D) \to -\infty \textit{ and } \lim_{\rho_D \to 0} Ce_d(\rho_D) = E\left[\tilde{u}_d\left(\tilde{x} - R\,\tilde{S}\right) \mid \tilde{y}^* = y^*\right] = -\lambda\,\sigma_d < 0.$$

<u>Proof</u>: The signs of the derivatives in (7.8) follow from differentiating (7.7) partially with respect to the relevant variables, and then choosing a set of parameters that fits. Finally, the limits in (7.9) follow analogously from the use of L` Hôpital's rule in (7.6). Q.E.D.

If the liquidity traders are risk neutral, the value of a random trading strategy is the expected profit. The trading risk given by (7.4) tends to increase with noise or liquidity trading, and to decrease by insider or other informed trading. It is therefore often called noise trader risk, but the noise trader risk is purely market created while the trading risk also depends on the fundamental risk. Noise traders creating risks are consistent with De Long, Shleifer, Summers, and Waldman (1990).

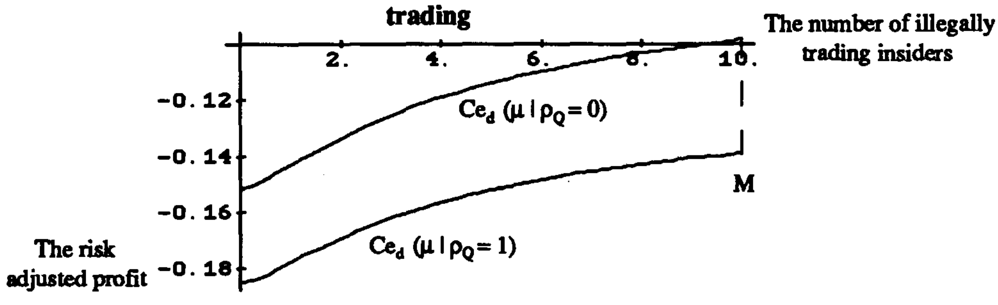
Proposition 7.15: *The value of following a random trading strategy <u>tends</u> to be a unimodal function in the supply of corporate insiders:*

$$(7.10) \qquad Sgn\left(\frac{d\,Ce_d}{d\,\mu}\right) = -\,Sgn(\mu_d - \mu).$$

where μ_d, among other things, is a function of ρ_D. If $\rho_D > \rho_D^{``}$ (where $\rho_D^{``}$ is a relatively large constant), then $\mu_d = 0$, implying that $Ce_d(\mu)$ is a monotonically increasing function for all μ.

Figure 7.7 illustrates Ce_d as a function of μ.

FIGURE 7.7 The value of random trading



I find that $Ce_d(\mu = 0 \mid \rho_Q = 1) = -0.185 < Ce_d{}^{\bullet}(\mu \rightarrow \infty \mid \rho_Q = 1) = -0.115$ and $Ce_d(\mu = 0 \mid \rho_Q = 0) = -0.152 < Ce_d{}^{\bullet}(\mu \rightarrow \infty \mid \rho_Q = 0) = -0.053$. The figure is consistent with the proposition above because $\rho_D = 1 > \rho_D{}^{``}$, which makes $Ce_d(\mu)$ monotonically increasing. Figure 7.5 implies that $\rho_D = 0 < \rho_D{}^{``}$, making $Ce_d(\mu) = -\lambda(\mu)\ \sigma_d$ unimodal.

Proposition 7.16: *Suppose the stock market equilibrium is given by (3.1) - 3.10), then*

$$\frac{\partial Ce_d}{\partial \text{as}} < 0,\ \frac{\partial Ce_d}{\partial \text{rc}} < 0,\ \textit{and}\ \frac{\partial Ce_d}{\partial \text{re}_d} < 0, \tag{7.11}$$

where

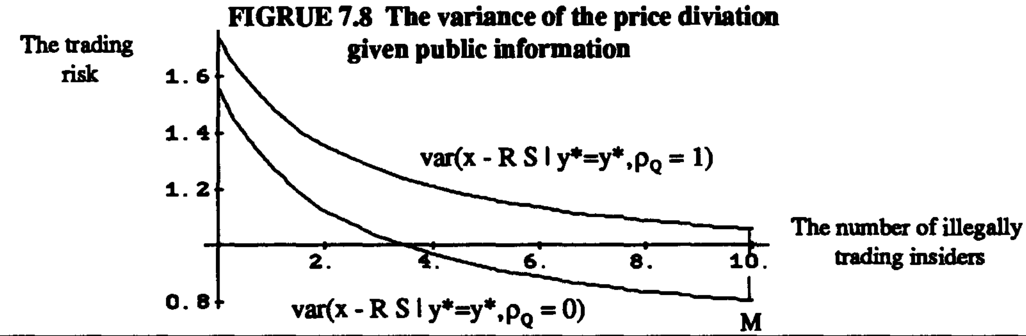
$$\text{re}_d = \sigma_d \operatorname{var}\left(\tilde{x} - R\,\tilde{S} \mid \tilde{y}^* = y^*\right). \tag{7.12}$$

<u>Proof</u>: According to (5.1) and (5.3), as and rc increases λ, and, according to (7.8), the parameters λ, σ_d, and var(x - R S | y*=y*) decrease Ce_d. Q.E.D.

The risk adjusted trading cost of liquidity traders decreases if the price setting market makers face an increased adverse selection problem, the market makers have to be compensated more for the risk of trading against the order flow, or the risk exposure of the liquidity trader increases. Moreover, the supply of corporate insiders influences Ce_d through these components. Both as(μ) and rc(μ) were analyzed in section 7.5, allowing me to concentrate on $re_d(\mu)$.

Figure 7.8 illustrates how the risk of trading at an unfavorable price depends on the supply of corporate insiders.

FIGRUE 7.8 The variance of the price diviation given public information



As we see, insider trading reduces the variance of the price deviation (from 1.735 towards 0.902 when $\rho_Q = 0$ and from 1.560 towards 0.618 when $\rho_Q = 1$), suggesting that the risk exposure of liquidity traders is improving with μ. This is because insider trading increases the price informativeness and therefore reduces the risk of trading at an unfavorable price.

Table 7.1 summarizes the identified effects caused by corporate employees trading on inside information on the welfare of liquidity traders.

TABLE 7.1: Effects on Ce_d caused by $\Delta\mu$

$\Delta\mu$	as	rc	re_d	Total
$\mu \in [0, \mu_d]$	-	+	+	-
$\mu \in (\mu_d, \mu_\lambda]$	-	+	+	+
$\mu \in (\mu_\lambda, \infty)$	+	+	+	+

as = adverse selection, rc = risk compensation, re_d = risk exposure, and μ_d, μ_λ are constants.

If the supply of insiders increases from zero to $\mu_d \geq 0$, the total effect on the welfare of liquidity traders tends to be negative due to the strong negative adverse selection effect. However, if the supply increases further, the total effect is positive.

Corporate insiders

As in Admati and Pfleiderer (1988a) and Subrahmanyam (1991), the value of insider trading is measured by the certainty equivalent or the expected risk adjusted profit. Due to the complete camouflage supplied by the noise traders, the illegally trading insiders take the probability of being caught by the stock market regulators to be zero.

Lemma 7.5: *The risk adjusted value of inside information is*

$$\text{(7.13)} \qquad Ce_m = \frac{1}{2\,\rho_M} \log\left(\left(\begin{matrix} 1 + \\ \rho_M \operatorname{cov}\left(\tilde{\Delta}_m,\, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\end{matrix}\right)^2 - \rho_M^2 \left[\begin{matrix}\operatorname{var}\left(\tilde{\Delta}_m \mid \tilde{y}^* = y^*\right) \cdot \\ \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\end{matrix}\right]\right),$$

where the variance of the pricing error is given by (7.4),

$$\text{(7.14)} \qquad \operatorname{cov}\left(\tilde{\Delta}_m,\, \tilde{x} - R\,\tilde{S} \mid \tilde{y}^* = y^*\right) = B\left[\left(1 - \lambda\,(N\,\beta + M\,B)\right)\Gamma - M\,B\,\lambda\,\eta\right], \textit{ and}$$

$$\text{(7.15)} \qquad \operatorname{var}\left(\tilde{\Delta}_m \mid \tilde{y}^* = y^*\right) = B^2\,(\Gamma + \eta).$$

<u>Proof</u>: See appendix B.

The risk adjusted value of inside information is the expected profit from insider trading minus an appropriate risk premium.

Proposition 7.17: *Suppose the stock market exchange is given by (3.1) - (3.10), then*

$$(7.16)\ \frac{\partial\, \mathrm{Ce_m}}{\partial\, \mathrm{cov}\left(\tilde{\Delta}_m,\ \tilde{x}\ -\ R\,\tilde{S}\mid \tilde{y}^*=y^*\right)} > 0,\ \frac{\partial\, \mathrm{Ce_m}}{\partial\, \mathrm{var}\left(\tilde{\Delta}_m \mid \tilde{y}^*=y^*\right)} < 0,\ \frac{\partial\, \mathrm{Ce_m}}{\partial\, \mathrm{var}\left(\tilde{x}\ -\ R\,\tilde{S}\mid \tilde{y}^*=y^*\right)} < 0,$$

$$\text{and } \frac{\partial\, \mathrm{Ce_m}}{\partial\, \rho_M} < 0.$$

Proof: This follows by differentiating (7.13) with respect to the relevant variable holding other variables constant. Q.E.D.

In other words, the expected risk adjusted profit from insider trading in security k at time t increases if the correlation between the insider's trading strategy and the future value of the security increases, the correlation between the insider's trading strategy and the transaction price decreases, the variability in the insider's end-of-period position in the security decreases, the variability in the pricing error decreases, or the insider's risk aversion decreases.

***Proposition 7.18:** Suppose the stock market equilibrium is given by (3.1) - (3.10), then*

$$(7.17)\ \lim_{\rho_M \to \infty} \mathrm{Ce_m}(\rho_M) = 0 \text{ and } \lim_{\rho_M \to 0} \mathrm{Ce_m}(\rho_M) = E\left[\tilde{\Delta}_m \begin{pmatrix}\tilde{x}\ - \\ R\,\tilde{S}\end{pmatrix} \mid \tilde{y}^*=y^*\right] = \mathrm{cov}\left(\tilde{\Delta}_m,\ \tilde{x}\ -\ R\,\tilde{S}\mid \tilde{y}^*=y^*\right).$$

Proof: This follows analogously from the use of L'Hôpital's rule in (7.6). Q.E.D.

If the corporate insiders are risk neutral, the relevant measure of value is the expected profit. On the other hand, completely risk averse individuals have no use for superior information since they do not take any positions in the risky securities at all. Notice also that if the corporate insiders observe noise ($\eta \to \infty$), y is of no value in the security market.

***Proposition 7.19:** The value of inside information tends to be a monotonically decreasing function in the supply of corporate insiders:*

(7.18) $$\frac{d\,Ce_m}{d\,\mu} < 0.$$

Figure 7.9 illustrates how the value of observing the signal y depends on the number of traders sharing the signal.

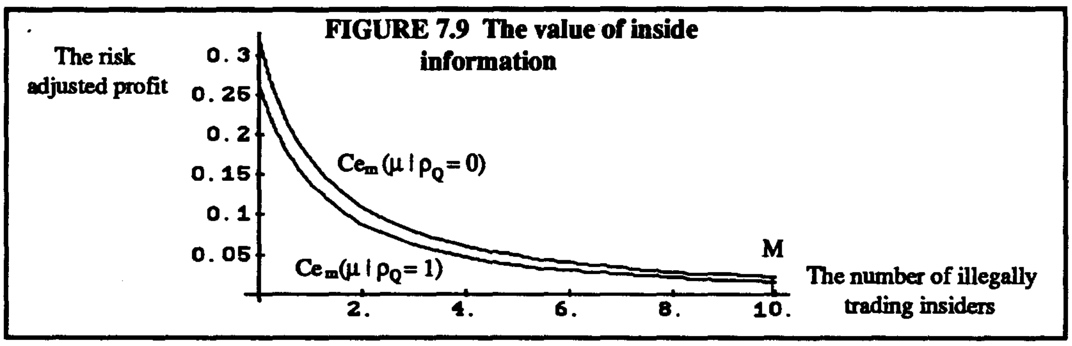


FIGURE 7.9 The value of inside information

We observe that $Ce_m{}^{\bullet}(\mu = 0 \mid \rho_Q = 0) = 0.319 > Ce_m(\mu \to \infty \mid \rho_Q = 0) = 0$ and $Ce_m{}^{\bullet}(\mu = 0 \mid \rho_Q = 1) = 0.261 > Ce_m(\mu \to \infty \mid \rho_Q = 1) = 0$.

The expected risk adjusted profit increases with expected profit and decreases with risk exposure where the risk aversion determines the weight on these two effects. Insider trading affects both the expected profit and the risk exposure. Table 7.2 summarizes the effects.

TABLE 7.2: Effects on Ce_m caused by $\Delta\mu$

$\Delta\mu$	ep_m	re_m	Total
$\mu \in [0, \infty)$	-	+	-

ep_m = expected profit and re_m = risk exposure.

More corporate insiders in the securities market reduces the expected profit of the insiders already in the market (see (3.3.4)), as well as the risk exposure. Nevertheless, the negative effect on expected profit tends to dominate the positive effect of risk exposure for all ρ_M. I may conclude that corporate insiders prefer insider trading allowed except insiders who plan and think they can get away with illegal trading on inside information.

Market professionals

The value of privately acquired information is measured by its certainty equivalent or the risk adjusted profit from trading. That is, the amount of money for which professional $n \in \{1, 2, ..., N\}$ is willing to sell y_n (and abstain from trading).

***Lemma** 7.5: The (gross) value of observing the signal y_n is*

(7.19) $$Ce_n = \frac{1}{2\rho_N} \log\left(\left(\begin{matrix} 1 + \\ \rho_N \operatorname{cov}\left(\tilde{\theta}_n, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\end{matrix}\right)^2 - \rho_N^2 \left[\begin{matrix}\operatorname{var}\left(\tilde{\theta}_n \mid \tilde{y}^* = y^*\right) \cdot \\ \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\end{matrix}\right]\right),$$

where the variance of the pricing error is given by (7.4),

(7.20) $$\operatorname{cov}\left(\tilde{\theta}_n, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right) = \beta\left[\left(1 - \lambda(N\beta + MB)\right)\Gamma - N\beta\lambda\varepsilon\right], \text{ and}$$

(7.21) $$\operatorname{var}\left(\tilde{\theta}_n \mid \tilde{y}^* = y^*\right) = \beta^2(\Gamma + \varepsilon).$$

Proof: See appendix B.

In this way, the properties of Ce_n are identical to the properties of Ce_m given in propositions 7.16 - 7.17, and the expected risk adjusted value of privately acquired information depends on the supply of corporate insiders in the financial market.

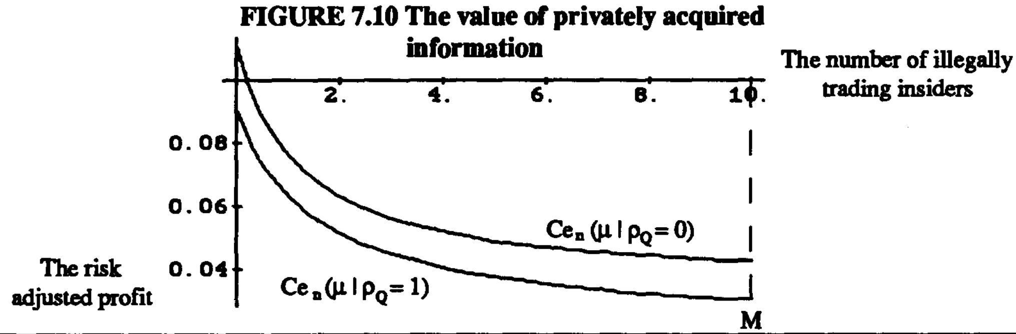
***Proposition** **7.20**: The value of private information tends to be a unimodal function in the supply of corporate insiders μ:*

$$(7.22) \qquad \mathrm{Sgn}\left(\frac{d\,Ce_n}{d\,\mu}\right) = -\,\mathrm{Sgn}(\mu_n - \mu),$$

where μ_n, among other things, is a function of $\rho = (\rho_N, \rho_M, \rho_Q)$. If $\rho = (0, 0, 0)$ and $\eta = 0$, $\mu_n \to \infty$ and $Ce_n(\mu)$ is a monotonically decreasing function (see (4.3.6) for a proof).

Figure 7.10 gives an example.

FIGURE 7.10 The value of privately acquired information



I find that $Ce_n\bullet(\mu = 0 \mid \rho_Q = 0) = 0.111 > Ce_n(\mu \to \infty \mid \rho_Q = 0) = 0.046$ and $Ce_n\bullet(\mu = 0 \mid \rho_Q = 1) = 0.091 > Ce_n(\mu \to \infty \mid \rho_Q = 1) = 0.021$. In this way, $Ce_n(\mu)$ falls monotonically when $\rho_Q = 1$ and is unimodal when $\rho_Q = 0$. For instance, $Ce_n(\mu = 10 \mid \rho_Q = 0) = 0.043 < Ce_n(\mu \to \infty \mid \rho_Q = 0) = 0.046$. This suggests that risk averse market professionals will vote in favor of a law prohibiting insider trading.

Proposition 7.21: *The value of privately acquired information depends on the trade-off between expected profit and risk exposure:*

$$(7.23) \qquad \frac{\partial Ce_n}{\partial E\left[\tilde{\theta}_n\left(\tilde{x} - R\,\tilde{S}\right) \mid \tilde{y}^* = y^*\right]} > 0 \textit{ and } \frac{\partial Ce_n}{\partial \mathrm{var}\left(\tilde{\theta}_n \mid \tilde{y}^* = y^*\right) \mathrm{var}\left(\tilde{x} - R\,\tilde{S} \mid \tilde{y}^* = y^*\right)} < 0.$$

<u>Proof</u>: This follows by differentiating (7.19) with respect to the relevant variables holding other variables constant. Q.E.D.

The expected risk adjusted profit of market professionals increases with expected profit from trading and decreases with risk exposure where the risk aversion ρ_N weighs the two effects. If $\rho_N = 0$, risk exposure has no weight, and if $\rho_N \to \infty$, the risk exposure is too great and no trade occurs. The effect on expected profit is discussed in section 4.3. The risk exposure of market professional n depends the risk of trading at a price which does not reflect the underlying value (i.e., $\mathrm{var}(x - R\,S \mid y^*=y^*)$) and size of the position taken in the securities market (i.e., $\mathrm{var}(\theta_n \mid y^*=y^*)$). According to (7.4), the risk tends to decrease when μ increases, and, according to (7.21), the position depends on the trading intensity and the precision of the signal. The trading intensity is analyzed in section 7.4.

If the supply of corporate insiders increases, the risk exposure of the market professionals tends to improve. This is because of a reduction in the risk of trading at an unfavorable price, and at the same time they respond by reducing their position in the risky security due to competition. Nevertheless, the risk exposure may increase for large μ because then the professional may take larger positions in the security due to improved adverse selection. Table 7.3 summarizes.

TABLE 7.3: **Effects on Ce_n caused by $\Delta\mu$**

$\Delta\mu$	ep_n	re_n	Total
$\mu \in [0, \mu_n]$	-	+	-
$\mu \in (\mu_n, \infty)$	+	+ / (-)	+ / (-)

ep_n = expected profit, re_n = risk exposure, and μ_n is a constant.

When the supply of corporate insiders increases exogenously, the expected profit from insider trading and the risk exposure are unimodal, decreases and then increases. I conclude that market professionals prefer L = B to L = A and the ban should be effectively enforced.

7.8 WHERE AND WHEN SHOULD DISCRETIONARY LIQUIDITY TRADERS TRADE?

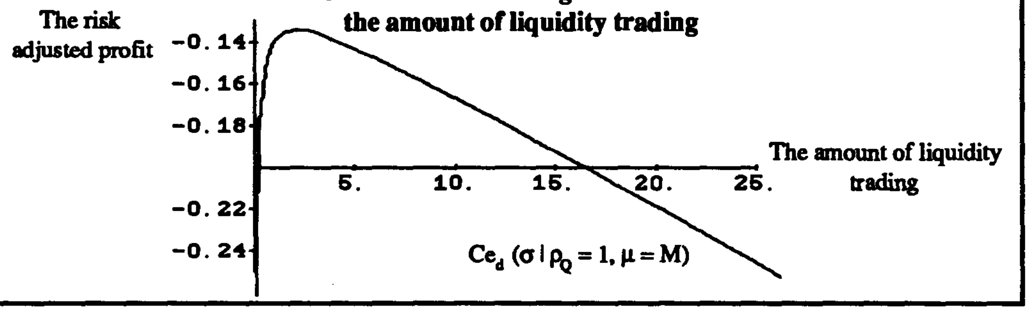
I concluded in section 4.6 that risk neutral security traders, both informed speculators and uninformed liquidity traders, should cluster their trades together with as many liquidity traders as possible, and the uninformed liquidity traders should also cluster with as many speculators as possible whereas the informed speculators should avoid trading together with other speculators (see Admati and Pfleiderer (1988b)). As observed by Subrahmanyam (1991), this is not necessarily the case in a corresponding market where the participants are risk averse.

Liquidity traders

Risk averse liquidity traders who are able to evaluate the securities and periods before they have to trade due to the realization of the liquidity events should, of course, trade u_d in security k at time t if $Ce_{dkt} \geq Ce_{dk`t`}$ for all $t` \in \{t\bullet, t\bullet\bullet\}$ and $k` \in \{k\bullet, k\bullet\bullet\}$.

Figure 7.7 implies that a discretionary liquidity trader should trade with as many insiders as possible (when $\rho_Q = 1$, this strategy gives a trading cost of 0.139). However, this need not to be an equilibrium. The reason is that clustering of liquidity trades is increasing the risk. Figure 7.11 illustrates.

FIGURE 7.11 The trading cost as a function of the amount of liquidity trading



We observe that in this example the trading cost of discretionary liquidity traders is minimized when the total amount of liquidity trading $\sigma = \sigma_d \approx 2$. This gives each liquidity trader an expected trading cost which equals

0.134. Complete clustering is not optimal as $Ce_d(\sigma)$ decreases when $\sigma > \sigma_d \approx 2$. This is never the case in a risk neutral market.

Proposition 7.22: *The welfare of liquidity traders* *<u>tends</u>* *to be a unimodal function in the total amount of liquidity trading:*

$$\text{(8.1)} \qquad \mathrm{Sgn}\left(\frac{d\, Ce_d}{d\,\sigma}\right) = \mathrm{Sgn}(\sigma_d - \sigma),$$

where σ_d, among other things, is a function of $\rho = (\rho_D, \rho_N, \rho_M, \rho_Q)$. If $\rho = (0, 0, 0, 0)$, $\sigma_d \to \infty$ and $Ce_d(\sigma)$ increases monotonically with σ.

As suggested by Subrahmanyam (1991) and Spiegel and Subrahmanyam (1992), the clustering equilibrium of Admati and Pfleiderer (1988) does not necessarily exist in a security market with risk averse participants. Nevertheless, when there are some informed trading, it is often optimal to cluster together with the informed speculators as is the case in the risk neutral market.

Informed speculators

Figure 7.10 indicates that market professionals prefer to trade when there are no corporate insiders in the security market (when $\rho_Q = 1$, this strategy gives a profit of 0.091). However, they prefer trading together with the liquidity traders as long as it is not too many such traders in the market.

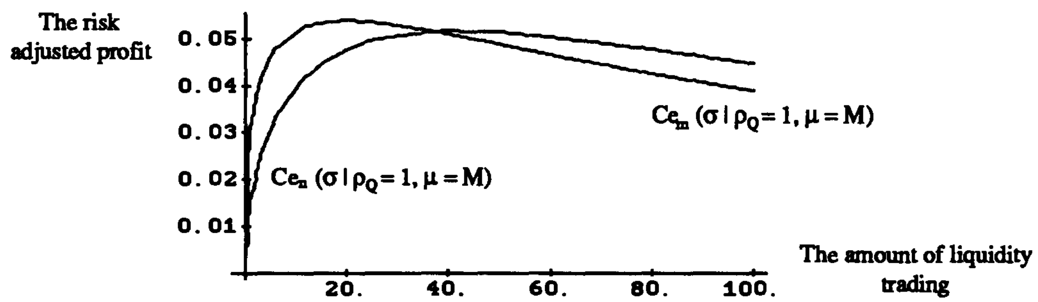
Proposition 7.23: *The value of privileged information* *<u>tends</u>* *to first increase and then decrease in the total amount of liquidity trading:*

$$\text{(8.2)} \qquad \mathrm{Sgn}\left(\frac{d\, Ce_n}{d\,\sigma}\right) = \mathrm{Sgn}(\sigma_n - \sigma) \textit{ and } \mathrm{Sgn}\left(\frac{d\, Ce_m}{d\,\sigma}\right) = \mathrm{Sgn}(\sigma_m - \sigma),$$

where σ_n and σ_m, among other things, are functions of $\rho = (\rho_N, \rho_M, \rho_Q)$. If ρ = (0, 0, 0), then the value of privileged information is increasing monotonically in σ.

Figure 7.12 illustrates when I assume that L = A.

FIGURE 7.12 The value of information as a function of the amount of liquidty trading



In this example, Ce_n and Ce_m are unimodal functions which suggest that the informed and risk averse speculators may prefer a reduction in the supply of uninformed traders. This is never the case in a similar risk neutral market because noise trader risk is not relevant.

7.9 SHORT SUMMARY OF MAJOR CONCLUSIONS

I have shown that insider trading influences the individual risk adjusted profit of all the demanders of immediacy (whereas the suppliers of immediacy are assumed to expect no risk adjusted profit whatever the insiders are doing). The following conclusions are drawn from the analysis:

- The liquidity traders tend to prefer insider trading allowed because the presence of several corporate insiders decreases the risk adjusted trading cost of traders trading to satisfy their liquidity needs. This is because insider trading reduces adverse selection, risk compensation, and risk exposure.
- The corporate insiders who are forced out of the market by the stock market regulators tend to prefer insider trading allowed. But if some of the insiders believe they are among the insiders who are able to trade illegally without being discovered, they prefer insider trading prohibited. This is mainly because

of the reduction in competition, but also factors such as reduced risk exposure are important in this picture.

- The market professionals prefer insider trading prohibited because insider trading reveals information and thereby reduces the possibilities of informed outsiders to make supernormal profits in the financial market. Nevertheless, the risk reducing properties of insider trading are viewed as desirable by outside professionals.
- Since I have assumed price taking behavior in the dealership market, the welfare of market makers is zero for every supply of corporate insiders. This suggests that the market makers are indifferent to whether insider trading should be prohibited or not.

I use the next chapter to extend the equilibrium in this chapter to a similar stock market economy where the welfare of market makers depends on the supply of corporate insiders due to imperfect competition in the dealership market. The lack of competition is partly compensated by introducing a new group of traders, the broker - arbitrageurs, who trade as the market makers based on information revealed by the net order flow. Finally, the semi-rational liquidity traders are replaced by fully rational hedgers trading to hedge their initial position.

APPENDICES

This section contains of the formal proofs, and the last appendix gives the numerical values used in the example.

Appendix A Proof of lemma 7.1

I draw on the proof of lemma 2.1 given in appendix 2.A and extend it to the case where all the participants are risk averse.

The portfolio-selection problem of market professional $n \in \{1, 2, ..., N\}$ is given by (2.2). If $\rho_N = 0$, (2.2) is identical to (2.2.11). I follow the derivation of the professionals' trading strategy in appendix 2.A (see (2.A15) - (2.A29)), and obtain the trading strategy given by (3.1) where the trading intensity (see (2.A28) for the limit when $\rho_N = 0$)

$$\text{(A1)} \qquad \beta = \frac{\left[1 - \lambda\left((N-1)\beta + MB\right)\right]\Gamma}{(\Gamma + \varepsilon)\left[2\lambda + \rho_N \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}_n, \tilde{y}^* = y^*\right)\right]}.$$

I solve for β, taking the variance of the price deviation as a constant, and obtain the trading intensity given by (3.3). Then I use the price function given by (2.6) where the net order flow is given by (2.A31) and yield (3.5). The second order condition (adjust (2.A17) and differentiate with respect to θ_n) is

$$\text{(A2)} \qquad -\left[2\lambda + \rho_N \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}_n, \tilde{y}^* = y^*\right)\right] < 0.$$

If $\rho_N \geq 0$ and $\lambda \geq 0$ (with at least one strict inequality), (A3) is satisfied because var(x - R S | y_n, y^*=y^*) is always non-negative.

The portfolio-selection problem of corporate insider $m \in \{1, 2, ..., M\}$ is given (2.3). If $\rho_M = 0$, (2.3) is identical to (2.2.12). I follow the derivation of the insider's trading strategy in appendix 2.A (see (2.A1) - (2.A14)), and obtain the trading strategy given by (3.2) where the trading intensity is given by (3.4) or, when $\rho_N = 0$, by (2.A14). Then I use (2.6) and (2.A31), and yield (3.6). The second order condition equals (adjust (2.A4) and differentiate with respect to Δ_m)

$$\text{(A3)} \qquad -\left[2\lambda + \rho_M \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}, \tilde{y}^* = y^*\right)\right] < 0.$$

If $\rho_M \geq 0$ and $\lambda \geq 0$ (with at least one strict inequality), the obtained trading intensity produces a maximum because the variance is always non-negative.

The risk averse and competitive market makers determine the transaction price according to the equilibrium condition in the dealership market given by (2.5); see also (2.6) and (2.7). The price function given by (3.7) and the price sensitivity given by (3.8) follow straightforwardly from (2.5) by the use of the rules for conditional expectation and conditional variance given normally distributed variables (see, e.g., Goldberger (1991), pages 75 - 76). This completes the proof of lemma 7.1.

Appendix B Proof of lemmas 7.3 - 7.6

I assume an exponential utility function $U(T\ (x - R\ S)) = -\exp\{-\ \rho\ T\ (x - R\ S)\}$ where ρ is the risk aversion coefficient and $T\ (x - R\ S)$ is the final wealth obtained by following the trading strategy $T \in \{\theta_n, \Delta_m, u_d, - z_q\}$. Let the vector $[\rho\ T, (x - R\ S)] \sim N(0, V)$, then (see, e.g., Subrahmanyam (1991), page 439)

(B1)
$$E\left[-\exp\left(-\rho\,\tilde{T}\left(\tilde{x} - R\,\tilde{S}\right)\right)\right] = -\left\{\left|I + V\begin{pmatrix}0 & 1\\ 1 & 0\end{pmatrix}\right|^{1/2}\right\}^{-1},$$

where I is the identity matrix and V is the variance-covariance matrix. The certainty equivalent is defined by $E[U(T\ (x - R\ S))] = U(Ce)$, or

(B2)
$$\left|I + V\begin{pmatrix}0 & 1\\ 1 & 0\end{pmatrix}\right|^{1/2} \exp\{-\rho\,Ce\} = 1.$$

This means that the value of following the trading strategy T is

(B3)
$$Ce = \frac{1}{2\rho}\log\left\{\left|I + V\begin{pmatrix}0 & 1\\ 1 & 0\end{pmatrix}\right|\right\}.$$

If T is based on private information, then Ce is the maximum that a trader would be willing to pay to become privately informed. This value is also given in Admati and Pfleiderer (1987, 1988a) on page 85 in their first article and on page 99 in their last article.

If the trader is a market maker who has to contribute to market clearing, $T = z_q$, $\rho = \rho_Q$, and the variance-covariance matrix

(B4)
$$V_q = \begin{pmatrix}\rho_Q^2\,\mathrm{var}\left(\tilde{z}_q \mid \tilde{y}^* = y^*\right) & \rho_Q\,\mathrm{cov}\left(\tilde{z}_q, \tilde{x} - R\,\tilde{S} \mid \tilde{y}^* = y^*\right)\\ \rho_Q\,\mathrm{cov}\left(\tilde{z}_q, \tilde{x} - R\,\tilde{S} \mid \tilde{y}^* = y^*\right) & \mathrm{var}\left(\tilde{x} - R\,\tilde{S} \mid \tilde{y}^* = y^*\right)\end{pmatrix}.$$

I insert this into (B3) and get the risk adjusted value of market making given by (7.1). The covariance and the variances are given by (7.2) - (7.4) and follow straightforwardly from the structure of the equilibrium (3.1) - (3.10).

The liquidity traders trade for reasons outside the model. In this case, $T = u_d$, $\rho = \rho_D$, and the variance-covariance matrix

$$\text{(B5)} \qquad V_d = \begin{pmatrix} \rho_D^2 \operatorname{var}(\tilde{u}_d \mid \tilde{y}^* = y^*) & \rho_D \operatorname{cov}(\tilde{u}_d, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*) \\ \rho_D \operatorname{cov}(\tilde{u}_d, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*) & \operatorname{var}(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*) \end{pmatrix}.$$

The covariance and the variances follow easily from the structure of the equilibrium. I insert them into (B3) and yield (7.7) where var(x - R S | y*=y*) is given by (7.4).

When the trader is a corporate insider who observes a signal y, $T = \Delta_m$, $\rho = \rho_M$, and the variance-covariance matrix is

$$\text{(B6)} \qquad V_m = \begin{pmatrix} \rho_M^2 \operatorname{var}(\tilde{\Delta}_m \mid \tilde{y}^* = y^*) & \rho_M \operatorname{cov}(\tilde{\Delta}_m, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*) \\ \rho_M \operatorname{cov}(\tilde{\Delta}_m, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*) & \operatorname{var}(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*) \end{pmatrix}.$$

I substitute this into (B3) and yield the risk adjusted value of inside information given by (7.13). The variances and the covariance are given by (7.4), (7.14), and (7.15). They follow easily from the structure of the equilibrium given by (3.1) - (3.10).

The market professionals acquire a private signal y_n which means that in this case $T = \theta_n$, $\rho = \rho_N$, and the variance-covariance matrix

$$\text{(B7)} \qquad V_n = \begin{pmatrix} \rho_N^2 \operatorname{var}(\tilde{\theta}_n \mid \tilde{y}^* = y^*) & \rho_N \operatorname{cov}(\tilde{\theta}_n, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*) \\ \rho_N \operatorname{cov}(\tilde{\theta}_n, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*) & \operatorname{var}(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*) \end{pmatrix}.$$

I substitute this into (B3) and yield the risk adjusted value of privately acquired information given by (7.19). The variances and covariance given by (7.4), (7.20), and (7.21) and follow easily from the structure of the equilibrium. This completes the proof of lemmas 7.3, 7.4, 7.5 and 7.6.

Appendix C Example

Table 7.4 gives the numerical values of the exogenous parameters used in the figures to illustrate the equilibrium.

TABLE 7.4:			**Numerical values used in the example**					
Γ	=	2	ρ_N	=	1	M	=	10
ε	=	2	ρ_M	=	1	μ	$\in$	$\{1, 2, ..., M\}$
η	=	1	ρ_Q	$\in$	$\{0, 1\}$	N	=	2
σ	=	1	ρ_D	=	1	D	=	10
σ_d	=	0.1	R	=	1	Q	=	4

In this example all the agents are equal with respect to risk aversion (except in the case where the pricing is risk neutral).

REFERENCES

Admati, A., and P. Pfleiderer, 1987, "Viable Allocations of Information in Financial Markets," Journal of Economic Theory, 74 - 115.

Admati, A., and P. Pfleiderer, 1988a, "Selling and Trading on Information in Financial Markets," American Economic Review, 96 - 103.

Admati, A., and P. Pfleiderer, 1988b, "A Theory of Intraday Patterns: Volume and Price Variability," Review of Financial Studies, 3 - 40.

Billingsley, P., 1986, "Probability and Measure," Wiley-Intersience.

Bossaerts, P., and E. Hughson, 1991, "Noisy Signalling in Financial Markets," Working Paper, California Institute of Technology, Pasadena.

Chiang, A. C, 1984, "Fundamental methods of Mathematical Economics," McGraw-Hill.

De Long, J. B., A. Shleifer, L. H. Summers, and R. J. Waldman, 1990, " Noise Trader Risk in Financial Markets," Journal of Political Economy, 703 - 738.

Duffie, D., 1992, "Dynamic Asset Pricing Theory," Princeton University Press.

Fudenberg, D., and J. Tirole, 1991, "Game Theory," MIT Press.

Goldberger, A. S., 1991, "A Course in Econometrics," Harvard University Press.

Hirshleifer, J. 1971, "The Private and Social Value of Information and the Reward to Incentive Activity," American Economic Review, 561 - 574.

Ho, T., and H. R. Stoll, 1981, "Optimal dealer pricing under transactions and return uncertainty", Journal of Financial Economics, 47 - 73.

King, M., and A. Röell, 1988, "Insider Trading," Economic Policy, 165 - 187.

Kyle, A. S., 1984, "Market Structure, Information, Futures Markets, and Price Formation," Chapter 2 in G. G. Storey, A. Schmitz, and A. H. Sarris (eds.) "International Agricultural Trade: Advanced Readings in Price Formation, Market Structure, and Price Instability, " Westview Press, 45 - 64.

Kyle, A. S., 1989a, "Informed Speculation with Imperfect Competition," Review of Economic Studies, 317 - 356.

Kyle, A. S., 1989b, "Imperfect Competition, Market Dynamics, and Regulatory Issues," Discussion in S. Bhattacharya and G. M. Constantinides, 1989, "Financial Markets and Incomplete Information: Frontiers of Modern Financial Theory," Volume 2, Rowman and Littlefield, 153 - 161.

Leland, H. E., 1992, "Insider Trading: Should it be Prohibited?" Journal of Political Economy, 859 - 887.

Spiegel, M., and A. Subrahmanyam, 1992, "Informed Speculation and Hedging in a Noncompetitive Securities Market," Review of Financial Studies, 307 - 329.

Subrahmanyam, A., 1991, "Risk Aversion, Market Liquidity, and Price Efficiency," Review of Financial Studies, 417 - 441.

Wilson, R., 1968, "The Theory of Syndicates," Econometrica, 119 - 132.

CHAPTER 8

HEDGING, ARBITRAGE AND DEALING IN A SECURITIES MARKET WITH INSIDER TRADING REGULATIONS

First draft: October 1991,
Current revision: December 1992.

ABSTRACT

This chapter focuses on the welfare effects of insider trading regulations in a simple exchange market where the intermediaries recognize their market power. Take, for instance, the uninformed hedgers whose welfare is shown to depend on their initial position and the net gain from hedging. The sign and the size of the gain depend on the effectiveness of the hedging strategy and its implementation costs. Insider trading transfers resolution of uncertainty from the future to the present period, and thereby reduces the effectiveness of hedging strategies via the so called Hirshleifer effect. This is because insider trading reveals information to the intermediaries. They are then able to set the transaction price nearer its underlying fundamental, making it hard to hedge the future value of the security by taking offsetting positions in the securities market. On the cost side, there are two effects. Insider trading widens the equilibrium bid ask spread because of increased adverse selection due to less hedging. This erodes market liquidity. On the other hand, insider trading decreases the trading risk because it brings the transaction price nearer to its underlying fundamental. The net effect depends on the trade-off between the Hirshleifer effect, which reduces the effectiveness of hedging, and the two cost effects working opposite of each other. I find that the Hirshleifer effect tends to dominate, and conclude that hedgers tend to prefer insider trading prohibited and enforced by the stock market regulators.

8.1 INTRODUCTION

The approach in this chapter draws on the securities market model characterized by lemma 7.1. But it makes two significant extensions so that the new equilibrium, characterized by lemma 8.1, allows me to evaluate the effects of insider trading regulations on the welfare of outsiders such as broker - arbitrageurs, market makers, and hedgers.

The first extension is to allow two types of competing intermediaries. Moreover, when these suppliers of immediacy determine the equilibrium bid ask spread, they recognize their market power. This recognition crystallizes in an additional component in the bid ask spread, reflecting imperfect competition. In this way, I extend the imperfect dealership market in Kyle (1984) to the case where there are broker - arbitrageurs competing with the market makers. Competition reduces the new market power component, and if there is perfect competition, it vanishes completely. The second extension is based on Spiegel and Subrahmanyam (1992) who, within a traditional Kyle-type of setting with one type of superiorly informed speculators, replace the semi-rational liquidity traders by fully rational hedgers whose demand for immediacy is motivated by a desire to cover their initial positions. However, Spiegel and Subrahmanyam do not recognize the market power of the price setting intermediaries.

The cost of these extensions is that the viability of the securities market is reduced. This is because the securities market tends to break down if the intermediaries have "too much" market power and/or the amount of hedging becomes "too low". Insider trading regulations may, consequently, influence the possibilities of market existence.

As in the previous chapters, I focus on what happens to the properties of the equilibrium when the supply of corporate insiders changes exogenously, for instance, because of a change in the law governing insider trading. The main conclusion is that security traders, except uninformed liquidity traders with an elastic demand and corporate insiders forced out of the market, tend to prefer insider trading prohibited by the stock market regulators. This conclusion is based on the fact that insider trading reduces the effectiveness of uninformed trading strategies such as hedging, and the securities market therefore tends to dry up, become illiquid, and volatile. In this way, the stock market regulators should intervene by outlawing the most highly informed trading.

My findings are consistent with Leland (1992), who in a slightly different setting analyzes whether insider trading should be prohibited or not. He concludes that

> "...insider trading increases the welfare of insiders - quite naturally, since they are excluded in the other case. More interestingly, the outsiders' utility (certainty equivalents) falls by more than half." (see his page 877).

The reason for this reduction in the expected welfare of outsiders is that insider trading accelerates the resolution of uncertainty by shifting uncertainty from future to current prices.

The plan for this chapter is as follows. The next section presents the altered assumptions relative to the trading model in the previous chapter, and section three outlines the equilibrium. Sections four to seven discuss the properties of the equilibrium, and section eight concludes. The formal proofs of the lemmas are found in the appendices.

8.2 ASSUMPTIONS

I draw on the trading model characterized by lemma 7.1, but extend it to a corresponding stock market economy where the liquidity traders are replaced by rational, wealth maximizing hedgers, and the market makers recognize their market power, but face competition from brokers and other arbitrageurs with access to the information in the trading system.

There are two types of individuals, the broker - arbitrageurs and the market makers, who supply immediacy and thereby represent the continuous presence in the securities market. Three types of individuals, the market professionals, the hedgers, and the corporate insiders, demand immediacy and thereby represent the willingness to trade rather than wait; see Grossman and Miller (1988), pages 618 - 619 for a general discussion on these matters. The orders from the various demanders of immediacy may be thought of as market orders whereas the orders from the various suppliers of immediacy may be thought of as limit orders. A market order is to be executed at the best price in the trading system while a limit order sets a limit on the price at which it can be executed; see, for instance, Schwartz (1988), page 17 for a discussion. Hence, immediacy is supplied by limit orders and consumed by market orders; see Amihud and Mendelson (1991), pages 79 - 81.

The behavior of market professionals and corporate insiders are discussed in section 7.2. One new assumption is added though; the informed speculators have not access to any valuable information in the trading system. This implies that their demand functions, denoted θ_n and Δ_m, depend only on their personal information which is represented by the signals y_n and y correlated with the future value of the security. Thus, $\theta_n = \theta_n(y_n)$ and $\Delta_m = \Delta_m(y)$. This means that the resulting equilibrium is not a rational expectations equilibrium where traders foresee the transaction price and therefore may use its information content to adjust their demands; see, e.g., Grossman (1981).

The uninformed hedgers are risk averse, and therefore have a desire at time $t \in \{0, 1, ..., T_k - 1\}$, represented by an exponential utility function with a common risk aversion coefficient ρ_H, to hedge or offset the risk associated with their initial positions in security $k \in \{1, 2, ..., K\}$. This means that the decision problem of hedger $h \in \{1, 2, ..., H\}$ is to maximize the risk adjusted profit given the knowledge of the hedger's own position in the security. Thus,

$$(2.1)\ \underset{\tilde{u}_h}{\mathrm{Max}}\ E\left[\left(\tilde{W}_h + \tilde{u}_h\right)\tilde{x} - \tilde{u}_h R \tilde{S} \mid \tilde{W}_h, \tilde{y}^* = y^*\right] - \frac{\rho_H}{2}\,\mathrm{var}\left(\left(\tilde{W}_h + \tilde{u}_h\right)\tilde{x} - \tilde{u}_h R \tilde{S} \mid \tilde{W}_h, \tilde{y}^* = y^*\right),$$

where $W_h \sim N(0, \omega)$ is the initial wealth and u_h is the order or trading strategy. After u_h is decided, the market order from hedger h is submitted, together with orders from the informed speculators, to the price setting market makers. I assume that the hedgers do not have access to the information in the trading system, and they cannot therefore operate partly as broker - arbitrageurs. This approach is identical to the one in Spiegel and Subrahmanyam (1992). If $W_h = 0$ and $u_h = u_d \sim N(0, \sigma_d)$ where $d \in \{0, 1, ..., D\}$, the hedgers become liquidity traders. In the same way, the randomly trading liquidity traders become hedgers with an endogenous demand if they already have a random position, and they determine their trading strategies in order to maximize expected utility.

There are also broker - arbitrageurs present in the securities market. These traders have no initial wealth, but maximize expected utility by issuing (limit) orders based on the information obtained by observing the order book. If their utility is exponential with a common risk aversion coefficient ρ_A, the portfolio-selection problem of arbitrageur $a \in \{1, 2, ..., A\}$ is

(2.2) $$\operatorname*{Max}_{\Lambda_a} E\left[\tilde{\Lambda}_a\left(\tilde{x} - R\tilde{S}\right) \mid \tilde{z}, \tilde{y}^* = y^*\right] - \frac{\rho_A}{2} \operatorname{var}\left(\tilde{\Lambda}_a\left(\tilde{x} - R\tilde{S}\right) \mid \tilde{z}, \tilde{y}^* = y^*\right),$$

where Λ_a is the limit order (which is a function of the transaction price), S is the transaction price, and z is the pooled order flow from the informed speculators and the uninformed hedgers. After they have decided their orders, the broker - arbitrageurs submit their orders to the price setting market makers who have the formal responsibility for market clearing.

The market makers have access to the order book where they observe the demand from the informed speculators and the uninformed hedgers and the competing supply from the broker - arbitrageurs. If necessary, they clear the market by supplying securities from their own inventory. In a viable market, the process of market clearing always produces a transaction price. I assume that the preferences of market makers are represented by an exponential utility function in which ρ_Q is their common risk aversion coefficient. This implies that the portfolio-selection problem of market maker $q \in \{1, 2, ..., Q\}$ is

(2.3) $$\operatorname*{Max}_{\Theta_q} E\left[\tilde{\Theta}_q\left(\tilde{x} - R\tilde{S}\right) \mid \tilde{z}, \tilde{y}^* = y^*\right] - \frac{\rho_Q}{2} \operatorname{var}\left(\tilde{\Theta}_q\left(\tilde{x} - R\tilde{S}\right) \mid \tilde{z}, \tilde{y}^* = y^*\right),$$

subject to the market clearing condition

(2.4) $$\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m + \sum_{h=1}^{H}\tilde{u}_h + \sum_{a=1}^{A}\tilde{\Lambda}_a + \sum_{q=1}^{Q}\tilde{\Theta}_q = 0,$$

where Θ_q is the market maker's position. Their net position has to be the opposite of the net position vis-à-vis the other traders.

Note that $z = \Sigma\theta_n + \Sigma\Delta_m + \Sigma u_h$ is the pooled order flow from the market professionals, the corporate insiders, and the hedgers. The net order flow is a valuable signal since, for instance, a positive order flow signals to its observers that the traded security is undervalued. Because the transaction price is produced by market clearing, it contains the information from the order flow. Remember that the market makers can distinguish the demand coming from speculators and hedgers from the supply coming from the broker - arbitrageurs. This means that it is enough to condition on z in (2.3). But, of course, the market makers cannot distinguish the orders coming from informed speculators from the orders coming from uninformed hedgers. This suggests that the intermediaries face an adverse selection or price differentiation problem to the pricing of securities.

Here the difference between the broker - arbitrageurs and the market makers is somewhat artificial, but the broker - arbitrageurs have no formal responsibility for market clearing whereas the market makers are in many ways exchange professionals who have a special responsibility to clear the market. This means that the market makers have to clear the market from their own inventory even if they temporarily expect to lose, and they have a responsibility to maintain a "fair and orderly" market. Nevertheless, these functions are not explicitly modelled. The intermediaries are wealth maximizing individuals as other traders, suggesting that the exchange itself is not a non-profit organization which is consistent with the view in Miller (1991), pages 128 - 130. Finally, the broker - arbitrageurs may be considered as a different type of market makers having different risk attitude. Arbitrage trading and traditional market making are essentially alternative technologies for providing market making services (see Holden (1991)).

8.3 EQUILIBRIUM

When it exists, a Nash-equilibrium is (i) a set of trading strategies $\{(\theta_{nkt}, \Delta_{mkt}, u_{hkt}, \Lambda_{akt}, \Theta_{qkt}); n \in \{1, 2, ..., N\}, m \in \{1, 2, ..., M\}, h \in \{1, 2, ..., H\}, a \in \{1, 2, ..., A\}, q \in \{1, 2, ..., Q\}, k \in \{1, 2, ..., K\}, t \in \{0, 1, ..., T_k - 1\}\}$ determined by rational agents which maximize expected utility and (ii) a price function S_{kt} determined by the intermediaries in order to clear the securities market so that the demand equals the supply of immediacy.

Lemma 8.1: *If it exists, a linear pooling of orders equilibrium in security $k \in \{1, 2, ..., K\}$ at the (call) auction at time $t \in \{0, 1, ..., T_k - 1\}$ is denoted $[(\theta_{nkt}, \Delta_{mkt}, u_{hkt}, \Lambda_{akt}, \Theta_{qkt}); S_{kt}]$. The trading strategies of market professionals, corporate insiders, hedgers, arbitrageurs, and market makers are*

$$\tilde{\theta}_n = \beta\left(\tilde{y}_n - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \tag{3.1}$$

$$\tilde{\Delta}_m = B\left(\tilde{y} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \tag{3.2}$$

$$\tilde{u}_h = -\nu \tilde{W}_h, \tag{3.3}$$

$$\tilde{\Lambda}_a = -\psi\left(R\tilde{S} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \textit{ and} \tag{3.4}$$

$$\tilde{\Theta}_q = -\upsilon\left(R\tilde{S} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \tag{3.5}$$

respectively. The trading intensities are characterized by

$$\beta = \frac{[1 - MB\lambda]\Gamma}{[(N+1)\Gamma + 2\varepsilon]\lambda + \rho_N \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}_n, \tilde{y}^* = y^*\right)(\Gamma + \varepsilon)}, \tag{3.6}$$

$$B = \frac{[1 - N\beta\lambda]\Gamma}{(\Gamma + \eta)\left\{(M+1)\lambda + \rho_M \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}, \tilde{y}^* = y^*\right)\right\}}, \tag{3.7}$$

$$\nu = \frac{\rho_H\left[1 - \lambda(N\beta + MB)\right]\Gamma}{2\lambda + \rho_H \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{u}_h, \tilde{y}^* = y^*\right)}, \tag{3.8}$$

$$\psi = \frac{\left[mp_Q\,\rho_Q + Q\,as\left(mp_Q - mp_A\right)\Psi\right]\Psi}{\left(\rho_A\,\rho_Q + \left(\rho_Q A + \rho_A Q\right) as\,\Psi\right) mp_A\, mp_Q}, \textit{ and} \tag{3.9}$$

$$\upsilon = \frac{\left[mp_A\,\rho_A + A\,as\left(mp_A - mp_Q\right)\Psi\right]\Psi}{\left(\rho_A\,\rho_Q + \left(\rho_Q A + \rho_A Q\right) as\,\Psi\right) mp_A\, mp_Q}, \tag{3.10}$$

where Ψ is given by (6.1),

$$\operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}_n, \tilde{y}^* = y^*\right) = \frac{\Gamma\varepsilon}{\Gamma + \varepsilon}\left[\frac{1 -}{\lambda\{(N-1)\beta + MB\}}\right]^2 + \lambda^2\left[\frac{(N-1)\beta^2\varepsilon +}{M^2 B^2 \eta + H\nu^2\omega}\right], \tag{3.11}$$

(3.12) $$\operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}, \tilde{y}^* = y^*\right) = \frac{\Gamma\eta}{\Gamma + \eta}\left[1 - N\beta\lambda\right]^2 + \lambda^2\left[N\beta^2\varepsilon + H\nu^2\omega\right],$$

(3.13) $$\operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{u}_h, \tilde{y}^* = y^*\right) = \Gamma\left[1 - \lambda\left(N\beta + MB\right)\right]^2 + \lambda^2\left\{\begin{matrix} N\beta^2\varepsilon + M^2B^2\eta \\ + (H-1)\nu^2\omega \end{matrix}\right\},$$

(3.14) $$mp_A = \frac{(A-1)\psi + Q\upsilon}{(A-2)\psi + Q\upsilon},$$

(3.15) $$mp_Q = \frac{(Q-1)\upsilon + A\psi}{(Q-2)\upsilon + A\psi}, \text{ and}$$

(3.16) $$as = \frac{(N\beta + MB)\Gamma}{(N\beta + MB)^2\Gamma + N\beta^2\varepsilon + M^2B^2\eta + H\nu^2\omega}.$$

The transaction price of security k at time t is

(3.17) $$\tilde{S} = \frac{1}{R}\left\{E[\tilde{x} \mid \tilde{y}^* = y^*] + \lambda\left(\sum_{n=1}^{N}\tilde{\theta}_n + \sum_{m=1}^{M}\tilde{\Delta}_m + \sum_{h=1}^{H}\tilde{u}_h\right)\right\},$$

where the price sensitivity

(3.18) $$\lambda = mp\,(as + rc),$$

where

(3.19) $$mp = \frac{A\rho_Q + Q\rho_A}{\rho_Q A\dfrac{(A-2)\psi + Q\upsilon}{(A-1)\psi + Q\upsilon} + \rho_A Q\dfrac{(Q-2)\upsilon + A\psi}{(Q-1)\upsilon + A\psi}}, \text{ and}$$

(3.20) $$rc = \frac{\rho_A\rho_Q\left(N\beta^2\varepsilon + M^2B^2\eta + H\nu^2\omega\right)\Gamma}{\left(A\rho_Q + Q\rho_A\right)\left[(N\beta + MB)^2\Gamma + N\beta^2\varepsilon + M^2B^2\eta + H\nu^2\omega\right]}.$$

If L = B, then μ replaces M.

Proof: See appendix A.

This lemma extends lemma 7.1 to a corresponding stock market economy where (i) price setting market makers compete with broker - arbitrageurs with access to valuable information in the trading system (i.e., the order book), (ii) the intermediaries do not behave competitively but strategically, and (iii) the semi-rational liquidity traders are replaced by fully rational hedgers. In this way, the equilibrium is very general by having many of the properties of real securities markets. It is straightforward to adjust the equilibrium back to the case where the liquidity traders replace the hedgers, or to extend it to a corresponding stock market economy with both liquidity traders and hedgers. This adjustment would improve the viability of the equilibrium. Further extensions are possible.

Some special cases

In this subsection, I concentrate on the difference between my model and the ones in Spiegel and Subrahmanyam (1992).

Corollary 8.1: *Suppose there is one market maker or specialist acting competitively (thus, $Q = 1$), $A = 0$, and $M = 0$, then the linear equilibrium $[(\theta_{nkt}, \Delta_{mkt}, u_{hkt}); S_{kt}]$ is given by (3.1) - (3.3) and (3.18) where the trading intensities and the price sensitivity are characterized by*

$$(3.21)\ \beta = \frac{\Gamma}{[(N+1)\Gamma + 2\varepsilon]\lambda + \rho_N\left[\varepsilon[1 - \lambda(N-1)\beta]^2\Gamma + \lambda^2\left[(N-1)\beta^2\varepsilon + H\nu^2\omega\right](\Gamma + \varepsilon)\right]},$$

$$(3.22)\qquad \nu = \frac{\rho_H[1 - N\lambda\beta]\Gamma}{2\lambda + \rho_H\left[\Gamma[1 - \lambda N\beta]^2 + \lambda^2\left\{N\beta^2\varepsilon + (H-1)\nu^2\omega\right\}\right]},\ and$$

$$\lambda = \frac{\left[N\beta + \frac{\rho_Q}{2}\left(N\beta^2 \varepsilon + H v^2 \omega\right)\right]\Gamma}{N\beta^2 (N\Gamma + \varepsilon) + H v^2 \omega}. \tag{3.23}$$

Proof: The trading intensities follow from (3.6) and (3.8), and the price sensitivity follows from (7.2.7) which is the corresponding price sensitivity in a perfectly competitive dealership market. Nevertheless, assuming competitive behavior when there is only a single specialist is odd. According to (3.10), the trading intensity of the market maker is $\upsilon = 1 / \lambda$. Q.E.D.

This corollary equals the most general equilibrium in Spiegel and Subrahmanyam (1992) given in their appendix B, pages 327 - 328. The equilibrium has no closed form solution as is the case for lemma 8.1. To obtain close form solution, we have to assume that both the superiorly informed speculators and the price setting market makers are risk neutral.

Corollary 8.2: *Suppose the Q price setting market makers act competitively, $A = 0$, $\rho_N = 0$, $\rho_M = 0$, $\rho_Q = 0$, and*

$$\rho_H^2 H \omega > \frac{4\left[N(\Gamma + \varepsilon) + M(\Gamma + \eta)\alpha^2\right]}{(\Gamma + 2\varepsilon)^2}, \tag{3.24}$$

then there exists a unique, linear equilibrium $[(\theta_{nkt}, \Delta_{mkt}, u_{hkt}); S_{kt}]$ given by (3.1), (3.2), (3.3), and (3.18). The trading intensities are

$$\beta = v\sqrt{\frac{H\omega}{N(\Gamma + \varepsilon) + M(\Gamma + \eta)\alpha^2}}, \tag{3.25}$$

$$B = \alpha v\sqrt{\frac{H\omega}{N(\Gamma + \varepsilon) + M(\Gamma + \eta)\alpha^2}}, \text{ and} \tag{3.26}$$

$$(3.27)\ \nu = \frac{\left[N\Gamma + (M+1)(\Gamma+\eta)\alpha\right]\left\{\rho_H(\Gamma + 2\varepsilon) - 2\sqrt{\frac{N(\Gamma+\varepsilon) + M(\Gamma+\eta)\alpha^2}{H\omega}}\right\}}{\rho_H\left\{(\Gamma + 2\varepsilon)^2 + \Gamma\left(N\varepsilon + M^2\alpha^2\eta\right) + \frac{(H-1)\left[N(\Gamma+\varepsilon) + M(\Gamma+\eta)\alpha^2\right]\Gamma}{H}\right\}},$$

where α is given by (2.3.6). The price sensitivity is

$$(3.28)\qquad \lambda = \frac{\Gamma}{\nu\left[N\Gamma + (M+1)(\Gamma+\eta)\alpha\right]}\sqrt{\frac{N(\Gamma+\varepsilon) + M(\Gamma+\eta)\alpha^2}{H\omega}}.$$

Finally, μ replaces M if $L = \boldsymbol{B}$.

Proof: The trading intensities follow from (3.6), (3.7), and (3.8) and the price sensitivity λ = as which, according to (3.18), is the price sensitivity in a securities market in which the market makers actually act competitively ($Q \to \infty$). The condition on existence follows from the second order conditions which imply that $\lambda > 0$. One way of satisfying this is to assume that $\nu > 0$; see Spiegel and Subrahmanyam (1992), page 327. Q.E.D.

This corollary extends lemma 2.1 to the case where the semi-rational liquidity traders are replaced by rational, wealth maximizing hedgers. Moreover, it also extends the stock market equilibrium given by proposition 1 in Spiegel and Subrahmanyam (1992) to the case where the superiorly informed traders trade on the basis of different-quality information. Thus, if $M = 0$, then corollary 8.2 equals their proposition 1 given on their page 313.

More on the existence of the equilibrium

Unlike the stock market equilibrium given by lemma 7.1, the equilibrium given by lemma 8.1 above may not exist.

Proposition 8.1: *Suppose $v > 0$ and $\lambda > 0$, then there exists a unique, linear equilibrium given by lemma 8.1. Otherwise, the equilibrium may break down.*

Proof: As indicated by (3.27), the trading intensity of the hedgers may become negative if, for instance, they are few in number. This means that the price sensitivity becomes a negative number which is not consistent with the second order conditions of the speculators' maximization problems. However, λ may become negative even when $v > 0$. This happens according to (3.18) when

(3.29) $$\rho_Q A \frac{(A - 2)\psi + Q\upsilon}{(A - 1)\psi + Q\upsilon} + \rho_A Q \frac{(Q - 2)\upsilon + A\psi}{(Q - 1)\upsilon + A\psi} < 0.$$

For instance, if $A = 0$ and $Q \leq 2$, then $\lambda \leq 0$ because $\mathbf{mp} \leq 0$. Finally, if $v > 0$ and $\lambda > 0$, the proof of the uniqueness follows along the same lines as the proof of the uniqueness of lemma 7.1; see proposition 7.1. Q.E.D.

The non-existence of the equilibrium happens in two cases: First, if the supply of immediacy is small, the intermediacy have "too much" market power as in Kyle (1984, 1989), and the market breaks down. Thus, there is no equilibrium unless there are enough broker - arbitrageurs and/or market makers to generate a sufficiently competitive trading environment. Secondly, if the presence of uninformed hedgers is small, informed traders are not able to hide in the pool of traders and, as in Spiegel and Subrahmanyam (1992), the market breaks down. In other words, a market collapse occurs when the uninformed hedgers refuse to trade with the informed speculators because the informational motive for trade outweighs their hedging motive. For such a result in a walrasian framework; see Bhattacharya and Spiegel (1991).

Insider trading and market breakdowns

As suggested by inequalities (3.27) and (3.29), the probability of market breakdowns is influenced by the number of corporate insiders "allowed" to operate in the securities market. The possibilities of market collapses therefore have implications for insider trading regulations.

Proposition 8.2: *Suppose the securities market is characterized by corollary 8.2 and*

$$\mu > \frac{\Gamma + \eta}{\eta}, \tag{3.30}$$

then the probability of a viable equilibrium increases with the supply of corporate insiders in an otherwise randomly given set of parameters. Nevertheless, if $\mu = 0$ and then increases to $M < (\Gamma + \eta) / \eta$, the probability of a market breakdown increases.

Proof: Given the assumption, the condition for a viable equilibrium is given by (3.24). We see that insider trading affects the right hand side of the inequality. It is straightforward to show that Sgn(d RHS / d M) = Sgn(Γ + (1 - M) η) where RHS means the right hand side, and condition (3.30) follows immediately. This means that the right hand side is a unimodal function which increases for small μ and decreases for larger μ. Q.E.D.

The desirable competition effects caused by extensive insider trading increases the viability of the market equilibrium. On the other hand, increased trading by the market professionals always increases the probability of a market breakdown. The reason is the differences in information structures between professionals and insiders; see section 2.2.

This result gives in some respects a more complicated picture of market breakdowns and informed trading than the ones given previously by Glosten and Milgrom (1985), Glosten (1989), Bhattacharya and Spiegel (1991), and Spiegel and Subrahmanyam (1992). They find that the market breaks down if there are "too much" informed trading. In my model, there may be infinitely many informed traders, and the securities market equilibrium may still exists. But since infinitely many corporate insiders reveal their information through trading, the amount of insider trading is limited (cf. (2.2.11)). This is the reason that securities markets may hold open even if there are infinitely many corporate insiders operating on information obtained from internal sources.

8.4 TRADING INTENSITIES

This section analyzes how the demand and supply of immediacy depend on the number of corporate insiders trading in the financial market and thereby on the exogenously determined insider trading regulations. The market is said to be immediate if an incoming order is executed immediately without any search for traders to take the opposite position. In this model, the motives for trading are information, risk sharing, and market power in the broker - dealership market.

Demanders of immediacy

The demanders are the informed speculators and the uninformed hedgers, but they have different motives for trading. The market professionals and the corporate insiders trade stocks based on privileged information whereas the hedgers trade to cover their initial position. Nevertheless, their trading intensities have several properties in common.

Proposition 8.3: *Suppose the stock market equilibrium is given by (3.1) - (3.20), then*

$$(4.1)\ \frac{\partial \beta}{\partial \operatorname{var}\left(\tilde{x} - R\,\tilde{S},\ \tilde{y}_n,\ \tilde{y}^* = y^*\right)} < 0,\ \frac{\partial B}{\partial \operatorname{var}\left(\tilde{x} - R\,\tilde{S},\ \tilde{y},\ \tilde{y}^* = y^*\right)} < 0,\ \frac{\partial v}{\partial \operatorname{var}\left(\tilde{x} - R\,\tilde{S},\ \tilde{y},\ \tilde{y}^* = y^*\right)} < 0,$$

$$\frac{\partial \beta}{\partial \lambda} < 0,\ \frac{\partial B}{\partial \lambda} < 0,\ \textit{and}\ \frac{\partial v}{\partial \lambda} < 0.$$

<u>Proof</u>: This is obtained by differentiating the trading intensities given by (3.6), (3.7), and (3.8) with respect to the relevant variables, holding other variables constant. Q.E.D.

Other things equal, the demanders of immediacy decrease their trading intensities when the trading risk (that is, the risk of trading at a price different from its underlying value) or the price sensitivity (and thereby the equilibrium bid ask spread) are increasing. There are also differences in the trading response between hedgers and speculators.

Proposition 8.4: Suppose the stock market equilibrium is given by (3.1) - (3.20), then

(4.2) $$\frac{\partial \beta}{\partial \rho_N} < 0, \ \frac{\partial B}{\partial \rho_M} < 0, \ \textit{and} \ \frac{\partial \nu}{\partial \rho_H} > 0.$$

Proof: This is obtained by differentiating (3.6), (3.7), and (3.8) with respect to the respective risk aversion coefficients, holding other variables constant. Q.E.D.

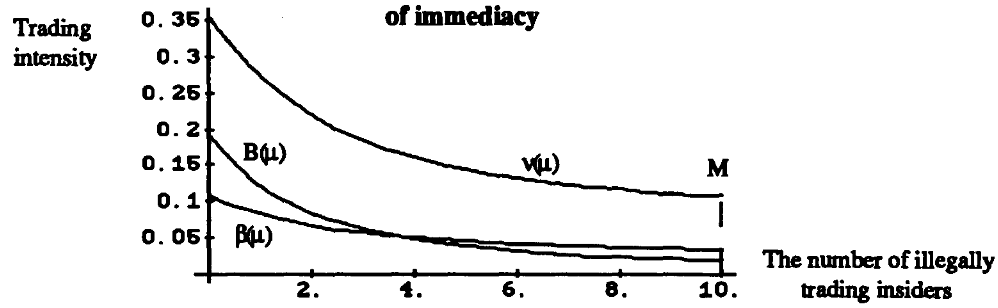
If their risk aversion increases, the trading intensities of informed speculators decrease while the trading intensity of uninformed hedgers increases. The hedgers, of course, want to increase the hedge of their initial position if they become more concerned about random fluctuations in the future value of the security. This is their motive for trading.

Proposition 8.5: The trading intensities of the demanders of immediacy tend to be reduced in the supply of corporate insiders:

(4.3) $$\frac{d\beta}{d\mu} < 0, \ \frac{dB}{d\mu} < 0, \ \textit{and} \ \frac{d\nu}{d\mu} < 0.$$

Figure 8.1 gives the trading intensities of the demanders of immediacy as functions of μ, using the numerical values given in table 8.3 (see appendix B).

FIGURE 8.1 The trading intensities of the demanders of immediacy



If the supply of corporate insiders decreases because of tightened enforcement of the ban against insider trading, the trading intensities of the market professionals, the remaining corporate insiders, and the hedgers increase monotonically. In the example, we observe that $\nu^{\bullet}(\mu = 0) = 0.355 > \nu(\mu = 10) = 0.072 > \nu(\mu \to \infty) = 0.068$, $B^{\bullet}(\mu = 0) = 0.192 > B(\mu = 10) = 0.0182 > B(\mu \to \infty) = 0$, and $\beta^{\bullet}(\mu = 0) = 0.109 > \beta(\mu = 10) = 0.033 > \beta(\mu \to \infty) = 0.022$.

We observe that if the corporate insiders grow in number, the uninformed hedgers respond by reducing their demand. One reason is that insiders reduce the effectiveness of spot hedging due to the leakage of information through their submission of orders to the price setting intermediaries. Thereby the insiders reduce the uncertainty associated with holding an uncovered position in security k from t to t+1. By doing this before the hedgers actually have insured their initial position by taking an offsetting position at the forthcoming batch auction, the insiders actually destroy some of the risk sharing possibilities. One extreme occurs if the current price for some reason reveals the future value of the security, because it then would be impossible to use the batch auction to hedge, and the hedging demand would be zero. On the other hand, insider trading reduces the risk of spot trading because the variance of the price deviation, given the hedger's own trade, is reduced from 2.403, when there are no corporate insiders, to 1.209, when there are ten insiders, and converges towards 1.041 when $\mu \to \infty$. Other things equal, this would, according to (4.1), increase the trading intensity of the hedgers. In this way, there is a trade-off between less hedging due to reduced risk sharing possibilities and increased hedging due to less risk of trading at the current spot price. I find that the negative effect on the effectiveness of hedging strategies tends to dominate the positive effect on the risk of taking a spot position to offset the initial risk. This gives an explanation why the trading intensity of uninformed hedgers is falling in the supply of corporate insiders.

The effects on the trading intensities of superiorly informed speculators are much the same as in section 7.4. However, there is a new effect caused by the endogenous reduction in the amount of uninformed trading. This effect reduces the informed trading in order not to reveal too much information when facing the price setting intermediaries.

Suppliers of immediacy

The supply of immediacy is delivered by the broker - arbitrageurs and the market makers. They are both trading and competing with information inferred from the order book which displays the net order flow from the demanders of immediacy. Their motive for trading is the possibility of exploiting their market power and thereby make a risk adjusted profit.

Proposition 8.6: *Suppose the stock market equilibrium is given by (3.1) - (3.20), then (for almost all parameter values)*

$$\frac{\partial \psi}{\partial \rho_A} < 0,\ \frac{\partial \psi}{\partial \mathbf{mp}_A} < 0,\ \frac{\partial \psi}{\partial \mathbf{mp}_Q} > 0,\ \frac{\partial \psi}{\partial \Psi} > 0,\ \frac{\partial \psi}{\partial \mathbf{as}} < 0,\ \frac{\partial \upsilon}{\partial \rho_Q} < 0,\ \frac{\partial \upsilon}{\partial \mathbf{mp}_Q} < 0,$$
$$\frac{\partial \upsilon}{\partial \mathbf{mp}_A} > 0,\ \frac{\partial \upsilon}{\partial \Psi} > 0,\ \textit{and}\ \frac{\partial \upsilon}{\partial \mathbf{as}} < 0. \tag{4.4}$$

Proof: This follows by differentiating (3.9) and (3.10) with respect to the relevant variables, holding other variables constant. Q.E.D.

Other thing equal, the trading intensity of the broker - arbitrageurs decreases when their risk aversion, market power, or their price differentiation problem is reduced. On the other hand, their trading intensity increases when the market power of professionals or the informativeness of the net order flow is increased. For instance, if the market power of the broker - arbitrageurs is reduced, they expect to earn less risk adjusted profit. Consequently, they respond by increasing their trading intensity in order to compensate for some of the reduction in expected profit.

Proposition 8.7: *The trading intensities of the suppliers of immediacy tend to decrease in the supply of corporate insiders:*

$$\frac{\mathrm{d}\,\psi}{\mathrm{d}\,\mu} < 0\ \textit{and}\ \frac{\mathrm{d}\,\upsilon}{\mathrm{d}\,\mu} < 0. \tag{4.5}$$

Figure 8.2 gives an example.

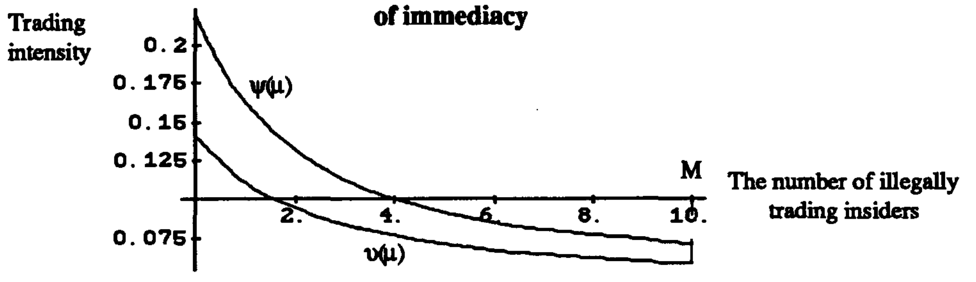


FIGURE 8.2 The trading intensities of the suppliers of immediacy

The limits are $\psi\bullet(\mu = 0) = 0.219 > \psi(\mu = 10) = 0.072 > \psi(\mu \to \infty) = 0.068$ and $\upsilon\bullet(\mu = 0) = 0.141 > \upsilon(\mu = 10) = 0.059 > \upsilon(\mu \to \infty) = 0.051$. In other words, the trading intensities of the suppliers of immediacy are monotonically decreasing functions in μ. This is consistent with what we observed in the previous subsection, as, when the demand for immediacy falls, the supply of immediacy must fall in order to clear the securities market.

If μ increases, the intermediaries are facing a trade-off. They tend to increase their trading intensity because trading by corporate insiders increase the informativeness of the net order flow, which in turn reduces the risk of trading. But this effect is dominated by an effect working in the opposite direction caused by the worsening of their adverse selection problem due to relatively more informed than uninformed trading. The negative net effect leads to less enthusiasm for taking the opposite position vis-à-vis the demanders of immediacy. This is consistent with Leland (1992), who on page 877 finds that the average demand of competitive hedger - arbitrageurs falls if the law changes from prohibiting to allowing insider trading.

8.5 PRICE SENSITIVITY

The slope of the market clearing line is the intermediaries` response parameter to changes in the market conditions. If the slope increases, the equilibrium bid ask spread increases which in turn reduces the liquidity of the market. According to (3.18), the price sensitivity and thereby the equilibrium bid ask spread is split into three components:

(5.1) $$\text{Bid ask spread} = \text{market power}\,(\text{adverse selection} + \text{risk compensation}).$$

This relation means that the equilibrium bid ask spread, denoted $s = s(\lambda)$, equals the market power component multiplied by the sum of the adverse selection and the risk compensation components (see also (3.3.2)). This division of the spread is consistent with the discussion, e.g., in Schwartz (1988), pages 419 - 420.

Proposition 8.8: *Suppose the stock market equilibrium is given by (3.1) - (3.20), then*

(5.2) $$\frac{\partial \lambda}{\partial \mathbf{as}} > 0,\ \frac{\partial \lambda}{\partial \mathbf{mp}} > 0,\ \textit{and}\ \frac{\partial \lambda}{\partial \mathbf{rc}} > 0.$$

Proof: This follows directly by differentiating (3.18) with respect to the relevant variables, holding other variables constant. Q.E.D

Other things equal, the price sensitivity and thereby the equilibrium bid ask spread are widened if the market power, the adverse selection, or the risk compensation of the price setting intermediaries increases. Notice that $\mathbf{mp} > 1$ and reflects the competition in the broker - dealership market. The two other components are also present in (7.3.8).

Proposition 8.9: *Suppose the stock market equilibrium is given by (3.1) - (3.20), then*

(5.3) $$\lim_{\substack{A\to\infty \text{ and/or} \\ Q\to\infty}} \lambda(A, Q) = \mathbf{as}.$$

Proof: This follows directly from (3.18). Q.E.D.

This means that competition in the broker - dealership market tends to narrow the bid ask spread so that it only reflects adverse selection, and the pricing therefore tends to be risk neutral and the market power evaporates.

Proposition 8.10: *The price sensitivity and thereby the equilibrium bid ask spread* <u>*tend*</u> *to increase with the supply of corporate insiders:*

$$\frac{d\lambda}{d\mu} > 0 \textit{ and } \frac{ds}{d\mu} > 0. \tag{5.4}$$

Figure 8.3 illustrates.

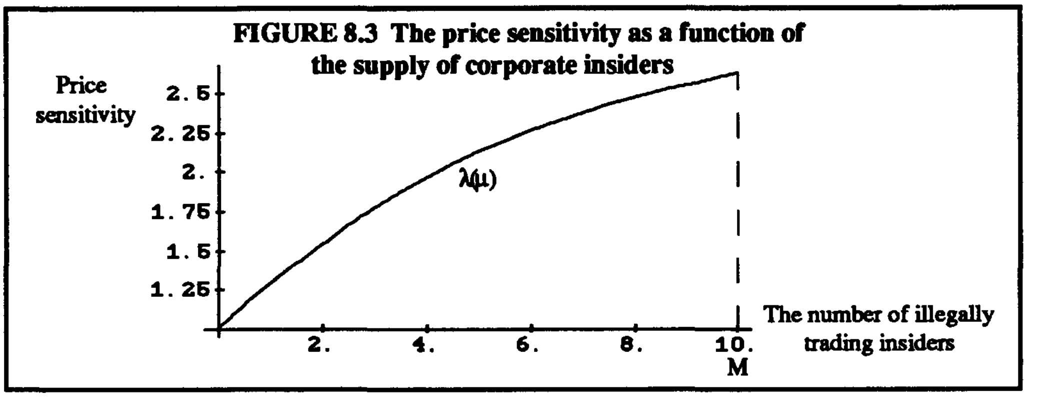
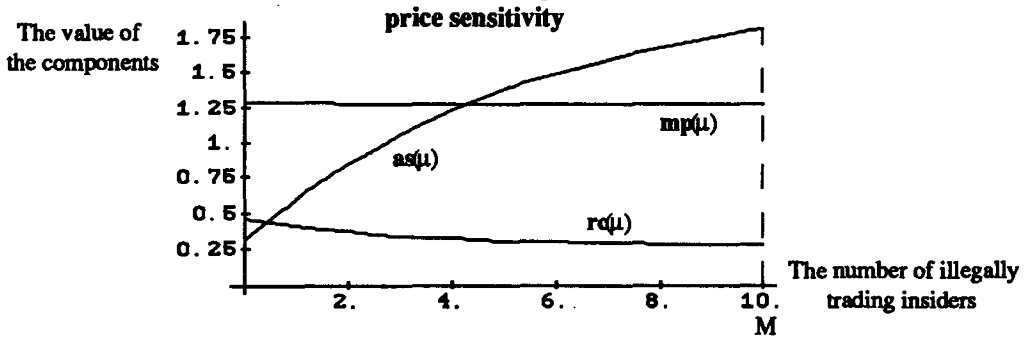


FIGURE 8.3 The price sensitivity as a function of the supply of corporate insiders

I find that $\lambda(\mu = 0) = 0.999 < \lambda(\mu = 10) = 2.633 < \lambda^{*}(\mu \to \infty) = 3.585$. Thus, the price sensitivity and thereby the equilibrium bid ask spread are increasing monotonically with the number of corporate insiders. This is consistent with the findings in Leland (1992), who on page 870 finds that the average price is increasing when insider trading is permitted. Here the equilibrium bid ask spread is increasing which leads to a higher transaction price; see also King and Röell (1988), page 168.

If the supply of corporate insiders increases, e.g., because of less enforcement from the stock market regulators, the net effect on the price sensitivity is determined by a trade-off between adverse selection, risk compensation, and market power. Figure 8.4 illustrates.

FIGURE 8.4 The components in the price sensitivity



I find that **as**(μ = 0) = 0.311 < **as**(μ = 10) = 1.807 < **as**•($\mu \rightarrow \infty$) = 2.606, **rc**•(μ = 0) = 0.466 > **rc**(μ = 10) = 0.275 > **rc**($\mu \rightarrow \infty$) = 0.239, and **mp**•(μ = 0) = 1.285 > **mp**(μ = 10) = 1.264 > **mp**($\mu \rightarrow \infty$) = 1.260. The adverse selection increases monotonically with μ whereas the risk compensation and the market power decrease monotonically. Notice that the price sensitivity can be found from the figure by the use of (3.18). For instance, $\lambda(\mu = 10) = 1.264\ (1.807 + 0.275) = 2.633$.

There are two important effects which affect the adverse selection component in the price sensitivity. These effects are called the competition and the hedger effect. First, for a given amount of hedging, the competition effect (through the sub-effect previously called the "presence-of-insider" effect) increases the adverse selection component when μ increases from zero to $\mu` \approx 1$ (where $\mu`$ is defined by d **as**($\mu`$) / d μ = 0 in a corresponding market without hedging). If μ increases to $\mu``$, where $\mu``$ is a constant satisfying $\mu` < \mu`` < M$, the competition effect ("lack-of-coordination") decreases the adverse selection component. Secondly, the trading intensity of the hedgers falls when μ increases. A decrease in the demand from uninformed traders tends to increase adverse selection because of the relative increase in informed traders. But there is also an opposite effect because informed speculators act strategically, and reduce their trading in order not to reveal too much information to the intermediaries. Nevertheless, the net effect increases the adverse selection because the competition effect tends to dominate the hedger effect. This is not necessarily the case if the corporate insiders observe diverse information; see Subrahmanyam and Spiegel (1992), pages 315 - 316. In this case, the net effect depends on the risk aversion of the uninformed hedgers which influences the change in the size of the uninformed orders. I find that when they are working in opposite directions, the hedger effect tends to dominate the competition effect. This also holds when the uninformed hedgers' risk aversion is large. Hence, the adverse selection tends to increase with μ.

The risk compensation component in the equilibrium price sensitivity decreases with the number of corporate insiders because an expansion in μ brings the transaction price closer to its fundamental. This implies that it is less risky to take the opposite position vis-à-vis the demanders of immediacy. Consequently, the intermediaries need not to quote as high a bid ask spread as is the case when there are fewer insiders, e.g., because $L = B$. When $A = 0$ or $Q = 0$, the market power component in the equilibrium price sensitivity is a constant independent of μ. This is also almost the case when there are two types of intermediaries. I find, however, that the market power decreases slightly as the intermediaries meet the order flow from less powerful demanders of immediacy.

8.6 MARKET EFFICIENCY

According to (3.18) and (3.20), the price sensitivity is closely related to the price informativeness. This relationship is caused by the component reflecting the risk compensation of the intermediaries; see section 7.5 for further comments.

Lemma 8.2: *The price informativeness is*

$$\Psi = \frac{1}{\Gamma} + \frac{(N\beta + MB)^2}{N\beta^2\varepsilon + M^2B^2\eta + H\nu^2\omega}. \tag{6.1}$$

Proof: The market efficiency is measured by (A11), and (6.1) follows straightforwardly from the structure of the equilibrium. Q.E.D.

Because the informed speculators are risk averse, the market efficiency depends on the amount of hedging. The reason is that speculators scale up their trades less than the increase in hedging; see Spiegel and Subrahmanyam (1992), who on page 318 analyze the case where hedging does not influence the informativeness of the transaction price.

Proposition 8.11: *Suppose the stock market equilibrium is given by (3.1) - (3.20), then*

$$(6.2)\ \frac{\partial \Psi}{\partial \Gamma} < 0,\ \frac{\partial \Psi}{\partial \beta} > 0,\ \frac{\partial \Psi}{\partial \mathrm{B}} > 0,\ \frac{\partial \Psi}{\partial \mathrm{N}} > 0,\ \frac{\partial \Psi}{\partial \mathrm{M}} > 0,\ \frac{\partial \Psi}{\partial \eta} < 0,\ \frac{\partial \Psi}{\partial \varepsilon} < 0,\ \frac{\partial \Psi}{\partial v} < 0,$$

$$\frac{\partial \Psi}{\partial \mathrm{H}} < 0,\ \textit{and}\ \frac{\partial \Psi}{\partial \omega} > 0.$$

Proof: This follows by differentiating (6.1) with respect to the relevant variables, holding other variables constant. Q.E.D.

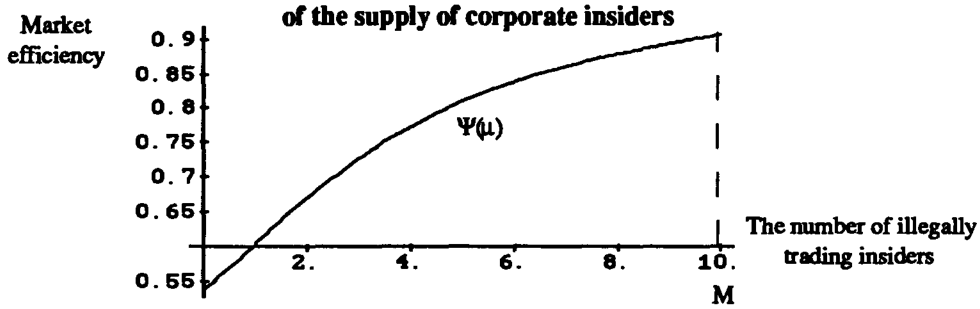
We see that the price informativeness increases with the amount of informed trading, but decreases with the amount of uninformed hedging.

Proposition 8.12: *The price informativeness tends to increase with the supply of corporate insiders and the precision of inside information:*

$$(6.3)\qquad \frac{d\Psi}{d\mu} > 0\ \textit{and}\ \frac{d\Psi}{d\eta} < 0.$$

Figure 8.5 gives Ψ as a function of μ.

FIGURE 8.5 The price informativeness as a function of the supply of corporate insiders



The limits are $\Psi(\mu = 0) = 0.536 < \Psi(\mu = 10) = 0.908 < \Psi^{\bullet}(\mu \to \infty) = 1.048$ where $\bullet$ indicates the maximum. I conclude that as long as the supply of market professionals is fixed or inelastic, the informativeness is improved by insider trading. Another indicator of market efficiency, the price volatility is also increasing when μ

increases due to a less enforcement of L = B.

8.7 WELFARE

This section analyzes the effects caused by an exogenous change in the number of corporate insiders on the welfare of all agents present in the economy characterized by lemma 8.1. As in Admati and Pfleiderer (1988), the welfare is measured by the expected risk adjusted profit which equals the expected profit minus an appropriate risk premium.

Suppliers of immediacy

The market makers and the broker - arbitrageurs recognize their market power, and expect accordingly to make a risk adjusted profit. As a result, the privilege to observe the order flow and set the transaction price becomes quite valuable. I show that the value of these privileges depends on the insider trading regulations, and because there often are close links between the exchange and the regulatory agency, the exchange becomes a powerful demander of regulation. The view that exchanges are profit maximizing organizations is consistent with the discussion in Miller (1991), pages 128 - 130.

Lemma 8.3: *The value of market making is*

$$(7.1)\ Ce_q = \frac{1}{2\rho_Q}\log\left\{\left[\frac{1+}{\rho_Q \operatorname{cov}\left(\tilde{\Theta}_q, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)}\right]^2 - \rho_Q^2 \operatorname{var}\left(\tilde{\Theta}_q \mid \tilde{y}^* = y^*\right) \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\right\},$$

where

$$(7.2)\quad \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right) = \Gamma\left[1 - \lambda\left(N\beta + MB\right)\right]^2 + \lambda^2\left[N\beta^2\varepsilon + M^2B^2\eta + Hv^2\omega\right],$$

$$(7.3)\quad \operatorname{var}\left(\tilde{\Theta}_q \mid \tilde{y}^* = y^*\right) = \upsilon^2\lambda^2\left[\left(N\beta + MB\right)^2\Gamma + N\beta^2\varepsilon + M^2B^2\eta + Hv^2\omega\right], \textit{ and}$$

$$(7.4)\ \operatorname{cov}\left(\tilde{\Theta}_q,\ \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right) = \upsilon\lambda\left[\begin{pmatrix} N\beta + \\ MB \end{pmatrix}\begin{Bmatrix} \lambda(N\beta + MB) \\ -1 \end{Bmatrix}\Gamma + \lambda\begin{Bmatrix} N\beta^2\varepsilon + M^2B^2\eta \\ + H\nu^2\omega \end{Bmatrix}\right].$$

In the same way, the individual value of observing the order book without any formal responsibility of market clearing is

$$(7.5)\ Ce_a = \frac{1}{2\rho_A}\log\left\{\left[\begin{matrix} 1 + \\ \rho_A \operatorname{cov}\left(\tilde{\Lambda}_a,\ \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\end{matrix}\right]^2 - \rho_A^2 \operatorname{var}\left(\tilde{\Lambda}_a \mid \tilde{y}^* = y^*\right)\operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\right\},$$

where

$$(7.6)\qquad \operatorname{var}\left(\tilde{\Lambda}_a \mid \tilde{y}^* = y^*\right) = \psi^2\lambda^2\left[(N\beta + MB)^2\Gamma + N\beta^2\varepsilon + M^2B^2\eta + H\nu^2\omega\right],\ \textit{and}$$

$$(7.7)\ \operatorname{cov}\left(\tilde{\Lambda}_a,\ \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right) = \psi\lambda\left[\begin{pmatrix} N\beta + \\ MB \end{pmatrix}\begin{Bmatrix} \lambda(N\beta + MB) \\ -1 \end{Bmatrix}\Gamma - \lambda\begin{Bmatrix} N\beta^2\varepsilon + M^2B^2\eta \\ + H\nu^2\omega \end{Bmatrix}\right].$$

<u>Proof</u>: The values given by (7.1) and (7.5) follow from (7.B3), and the variances and covariances given by (7.2) - (7.4) and (7.6) - (7.7) follow easily from the structure of the securities market equilibrium given by lemma 8.1. Q.E.D.

The value of observing the net order flow depends on the trade-off between expected profit and risk exposure where the risk aversion decide the weight of these two effects. For instance, if the supplier of immediacy is relatively risk averse, the deduction because of trading risk becomes more important. Otherwise, it is sufficient to analyze the effect on expected profit.

Proposition 8.13: *The value of observing the order flow <u>tends</u> to be a monotonically decreasing function in the supply of corporate insiders:*

$$(7.8) \qquad \frac{d\,Ce_q}{d\,\mu} < 0 \;and\; \frac{d\,Ce_a}{d\,\mu} < 0.$$

Figure 8.6 illustrates.

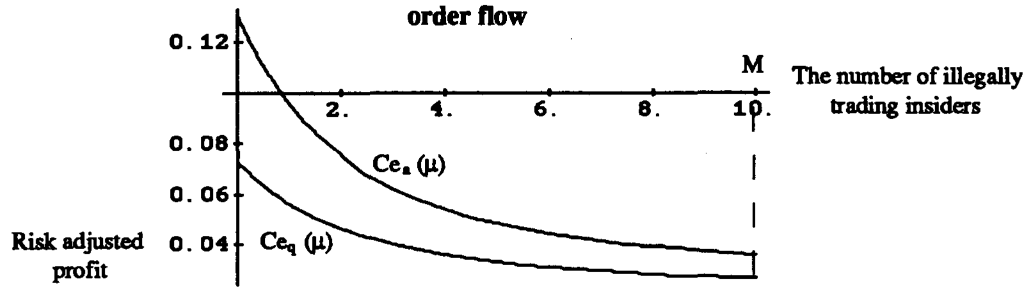


FIGURE 8.6 The value of observing the order flow

In this example, $Ce\bullet_a(\mu = 0) = 0.130 > Ce_a(\mu = 10) = 0.036 > Ce_a(\mu \rightarrow \infty) = 0.024$ and $Ce\bullet_q(\mu = 0) = 0.072 > Ce_q(\mu = 10) = 0.026 > Ce_q(\mu \rightarrow \infty) = 0.019$. $Ce_a(\mu) > Ce_q(\mu)$ because the broker - arbitrageurs are assumed to be fewer and less risk averse than the market makers. This means the broker - arbitrageurs have more use for the information content in the order flow from the demanders of immediacy because they respond harder to the information.

If the supply of corporate insiders increases, the effect on the expected profit depends on the sub-effects on the equilibrium bid ask spread and the expected trading volume. The first sub-effect is positive because insider trading reduces hedging, and lowers the adverse selection problem faced by the suppliers of immediacy. This forces the intermediaries to increase the price sensitivity and thereby the bid ask spread. The second sub-effect is negative because insider trading erodes market liquidity by reducing the trading from both the demander and suppliers of immediacy. In this way, the sub-effect on the equilibrium bid ask spread is positive, but the sub-effect on the expected trading volume is negative, because it reduces the expected welfare of the suppliers of immediacy.

If the supply of corporate insiders increases, the effect on risk exposure depends on their risk aversion and their trading risk. The risk aversion is independent of insider trading, whereas the trading risk depends on insider trading via its influence through the expected trading volume and the variability of the pricing error. Insider trading reduces the variability of the pricing error because information leaks out to the suppliers of immediacy via the net order flow, and they are therefore able to reduce the difference between the market price and its underlying fundamental. In this way, the effect on both the expected trading volume and the expected trading risk are positive because the risk premium is reduced, leading to higher expected welfare for the suppliers of immediacy.

Table 8.1 summarizes the effects.

TABLE 8.1: Effects on welfare caused by $\Delta\mu$

$\Delta\mu$	ep		re	Total
	bas	vol	dev	
$\mu = 0 \rightarrow \mu \leq M$	+	-/+	+	-

ep = expected profit, re = risk exposure, bas = bid ask spread, vol = trading volume, and dev = price deviation.

The net effect on the welfare of the suppliers of immediacy tends to be negative because insider trading reduces the expected trading volume and thereby the expected profit. But there are positive effects working through the bid ask spread and the trading risk.

The outsiders in Leland (1992) are as my arbitrageurs using the transaction price as their sole source of information. Although, his outsiders differ from my arbitrageurs since they have an initial wealth. The final conclusion is identical. The welfare of arbitrageurs increases if the law changes from allowing to prohibiting insider trading.

The demand for regulatory actions against insider trading may have many supporters in real world securities markets, but a condition for success is that powerful groups such as exchange members (market makers and brokers) are among the demanders to lobby the restrictions through the regulatory bureaucracy. Having exchange members on the team is an advantage because there often are close links between the national exchange and the regulatory agency. In this way, the stock market exchange often has a great impact on the national securities market law, at least in smaller countries.

Hedgers

The uninformed hedgers demand immediacy because they have a need to share the risk of holding the initial wealth from time t to time t+1, and a better allocation of risk improves their welfare. As we shall see, hedgers have much in common with liquidity traders. Nonetheless, the hedgers are fully rational while the liquidity traders are not.

Lemma 8.4: *The value of hedging the initial wealth of hedger $h \in \{1, 2, ..., H\}$ when the hedgers realize that they have a random endowment is*

$$(7.9)\ Ce_h = \frac{1}{2\rho_H}\log\left\{\left[\begin{matrix}1+\\ \rho_H \operatorname{cov}\left(\tilde{u}_h, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\end{matrix}\right]^2 - \rho_H^2 \operatorname{var}\left(\tilde{u}_h \mid \tilde{y}^* = y^*\right)\operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\right\},$$

where the variance of the pricing error is given by (7.2),

$$(7.10)\qquad \operatorname{var}\left(\tilde{u}_h \mid \tilde{y}^* = y^*\right) = \nu^2\,\omega, \textit{ and}$$

$$(7.11)\qquad \operatorname{cov}\left(\tilde{u}_h, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right) = -\lambda\,\nu^2\,\omega.$$

However, the expected utility when hedger h knows W_h is

$$(7.12)\ EU_h = \tilde{W}_h\, E\left[(1-\nu)\tilde{x} + \nu R\tilde{S} \mid \tilde{W}_h, \tilde{y}^* = y^*\right] - \frac{\rho_H}{2}\tilde{W}_h^2 \operatorname{var}\left((1-\nu)\tilde{x} + \nu R\tilde{S} \mid \tilde{W}_h, \tilde{y}^* = y^*\right),$$

where

$$(7.13)\qquad E\left[(1-\nu)\tilde{x} + \nu R\tilde{S} \mid \tilde{W}_h, \tilde{y}^* = y^*\right] = E[\tilde{x} \mid \tilde{y}^* = y^*] - \lambda\,\nu^2\,\tilde{W}_h, \textit{ and}$$

$$(7.14)\ \operatorname{var}\left((1-\nu)\tilde{x} + \nu R\tilde{S} \mid \tilde{W}_h, \tilde{y}^* = y^*\right) = \Gamma\left[1 - \nu\left\{\begin{matrix}1+\\ \lambda\,(N\beta + MB)\end{matrix}\right\}\right]^2 + \lambda^2\,\nu^2\left\{\begin{matrix}N\beta^2\,\varepsilon + M^2B^2\,\eta\\ +\ (H-1)\,\nu^2\,\omega\end{matrix}\right\}.$$

Proof: The value of hedging given by (7.9) follows from (7.B3), and the variance and the covariance given by (7.10) and (7.11) follow easily from the structure of the equilibrium. Then I insert (3.3) into (2.1), and yield the value of holding and hedging the initial position given by (7.12). The expectation and the variance given by (7.13) and (7.14) respectively follow straightforwardly from the structure of the equilibrium given by (3.1) - (3.20). Q.E.D.

The expected risk adjusted profit equals the expected profit minus an appropriate risk premium which reflects the risk of both holding and hedging the initial position. But the pure value of hedging given by (7.9) does not recognize the effects on the initial wealth, and the hedgers may therefore be considered as "liquidity traders" with an elastic demand. In this case, it is not optimal to hedge because $Ce_h < 0$ for all $v > 0$. This may seem strange, but it is caused by the fact that the trader does not know the risk caused by the initial position. However, if the hedgers know their initial wealth W_h, hedging is optimal, and hedging is therefore a part of the equilibrium. If $v = 0$, then, according to (7.12),

$$(7.15) \qquad \lim_{v \to 0} EU_h(v) = \tilde{W}_n E[\tilde{x} \mid \tilde{y}^* = y^*] - \tilde{W}_h^2 \frac{\rho_H}{2} \Gamma,$$

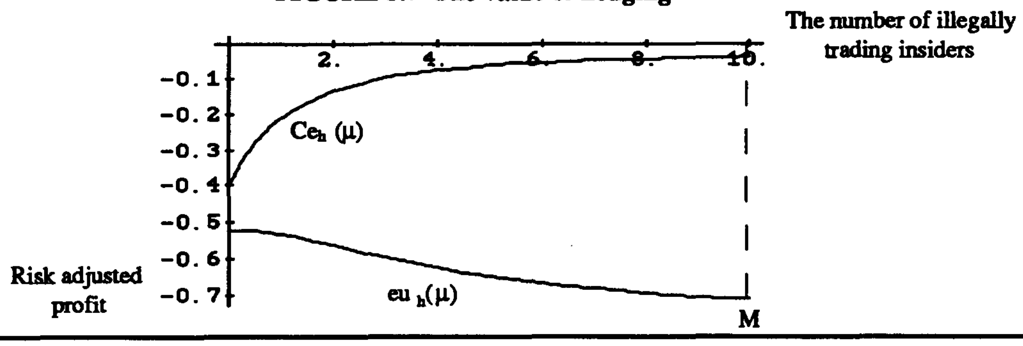
and by choosing $v > 0$, the hedgers obviously improve their expected utility. In fact there exist parameter values for which $v > 1$, suggesting, as also pointed out by Spiegel and Subrahmanyam (1992), pages 317 - 318, that the hedgers may "over-hedge".

Proposition 8.14: *The welfare of uninformed "liquidity traders" with an elastic demand of immediacy tends to improve with the supply of illegally trading insiders, whereas the welfare of uninformed hedgers tends to deteriorate:*

$$(7.16) \qquad \frac{d\,Ce_h}{d\mu} > 0 \textit{ and } \frac{d\,EU_h}{d\mu} < 0.$$

Figure 8.7 gives an example.

FIGURE 8.7 The value of hedging



I find that $Ce_h(\mu = 0) = -0.405 < Ce_h(\mu = 10) = -0.038 < Ce^{\bullet}{}_h(\mu \to \infty) = -0.020$ and $eu^{\bullet}{}_h(\mu = 0) = -0.522 > eu_h(\mu = 10) = -0.713 > eu_h(\mu \to \infty) = -0.797$ where $eu_h = (EU_h - W_h\ E[x \mid y^*=y^*]) / W_h{}^2$ depends on M (and thereby on μ) in the same way as EU_h.

In this example, the welfare of "liquidity traders" improves with μ and the welfare of hedgers worsen. If $v = 0$, $eu_h = -1$ for all μ which clearly illustrates that the hedger really has a rationale for trading because $eu_h(\mu) > -1$ for all $\mu \leq 10$. This is not the case with liquidity traders who are assumed to trade randomly (that is for exogenous reasons).

First, if we ignore the effects on the initial wealth of the hedgers, then, according to (7.9), the value of hedging depends on the expected trading cost and the risk exposure. According to (7.11), the expected trading cost depends on the bid ask spread and the position given by (7.10). I have found that insider trading increases the bid ask spread (see (5.4)), but decreases the positions of the hedgers (see (4.3)). Therefore the net effect on the expected profit is a trade-off between these two effects.

The risk exposure of the hedger depends on risk aversion and the risk of trading where the risk depends on the position taken and the variance of pricing error. I find that insider trading reduces both position (see (4.3)) and the variance of the price deviation given by (7.2). In this way, insider trading improves the risk exposure of "liquidity traders". This means that the effects of insider trading on expected trading profit and risk exposure tend to be positive, and so is the effect on the expected risk adjusted profit. The reason is that the net effect depends on its two sub-effects which are weighted by the risk aversion. For instance, if the hedgers are relatively risk averse, they pay much attention to the risk exposure, and they do not feel that insider trading is a problem because it reduces the trading risk.

Secondly, if the hedgers recognize their initial wealth, they also have to take into account the effect caused by insider trading on the possibilities of covering their position. We have seen that insider trading increases market efficiency (see (6.3)) and thereby decreases the riskiness of the future price, but increases simultaneously the volatility of the market price which, of course, measures the riskiness of the current transaction price. This transmission of risk from the future to the present period reduces the effectiveness of hedging strategies because there is reduced possibilities to hedge the future risk and a greater need to hedge the risk of trading together with corporate insiders creating variability in the transaction price. It is difficult to hedge against market created risks such as price volatility. The transmission effect tends to dominate the effects recognized by corresponding "liquidity traders".

Table 8.2 gives a summary the major effects affecting the welfare of both "liquidity traders" and real hedgers.

TABLE 8.2: Effect on welfare caused by $\Delta\mu$

$\Delta\mu$	ep	ep / re	re	wre	Total
	bas	vol	dev		
$\mu = 0 \rightarrow \mu \leq M$					
• "Liquidity traders"	-	+/+	+		+
• Hedgers	-	+/+	+	-	-

ep = expected profit, re = risk exposure of the traded position, bas = bid ask spread, vol = trading volume, dev = price deviation, and wre = risk exposure of the initial wealth.

The net effect on expected profit tends to be positive whereas the net effect on risk exposure is either positive or negative depending on the risk exposure of the initial wealth. In this way, the hedgers tends to prefer insider trading prohibited.

My finding is consistent with the finding in Spiegel and Subrahmanyam (1992), pages 320 - 321 (see, especially, their proposition 5). The outsiders in Leland (1992) have an initial wealth as my hedgers. This suggests that some of their demand is motivated by hedging, and this is used by Leland to explain why the welfare of outsiders increases when the law changes from allowing to prohibiting insider trading. He says that the distribution of risk is less desirable with insider trading (see his page 878). An early resolution of uncertainty may not always benefit market participants because it may destroy the possibilities of risk sharing; see Hirshleifer (1971).

Informed speculators

The corporate insiders and the market professionals expect to earn a risk adjusted profit on their superior information.

Lemma 8.5: *The value of insider trading is*

$$\text{(7.17)} \qquad Ce_m = \frac{1}{2\rho_M}\log\left\{\left[\begin{array}{c}1 + \\ \rho_M \operatorname{cov}\left(\tilde{\Delta}_m, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\end{array}\right]^2 - \rho_M^2\left[\begin{array}{c}\operatorname{var}\left(\tilde{\Delta}_m \mid \tilde{y}^* = y^*\right) \cdot \\ \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\end{array}\right]\right\},$$

where the variance of the pricing error is given by (7.2),

$$\text{(7.18)} \qquad \operatorname{var}\left(\tilde{\Delta}_m \mid \tilde{y}^* = y^*\right) = B^2(\Gamma + \eta), \textit{ and}$$

$$\text{(7.19)} \qquad \operatorname{cov}\left(\tilde{\Delta}_m, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right) = B\left[\left(1 - \lambda\left(N\beta + MB\right)\right)\Gamma - MB\lambda\eta\right].$$

The gross value of acquiring private information is

$$\text{(7.20)} \qquad Ce_n = \frac{1}{2\rho_N}\log\left\{\left[\begin{array}{c}1 + \\ \rho_N \operatorname{cov}\left(\tilde{\theta}_n, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\end{array}\right]^2 - \rho_N^2\left[\begin{array}{c}\operatorname{var}\left(\tilde{\theta}_n \mid \tilde{y}^* = y^*\right) \cdot \\ \operatorname{var}\left(\tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right)\end{array}\right]\right\},$$

where

$$\text{(7.21)} \qquad \operatorname{var}\left(\tilde{\theta}_n \mid \tilde{y}^* = y^*\right) = \beta^2(\Gamma + \varepsilon), \textit{ and}$$

(7.22) $$\operatorname{cov}\left(\tilde{\theta}_n, \tilde{x} - R\tilde{S} \mid \tilde{y}^* = y^*\right) = \beta\left[\left(1 - \lambda\left(N\beta + MB\right)\right)\Gamma - N\beta\lambda\varepsilon\right].$$

Proof: The values given by (7.17) and (7.20) follow from (7.B3), and the variances and the covariances given by (7.18), (7.19), (7.21), and (7.22) follow straightforwardly from the structure of the equilibrium (3.1) - (3.20). Q.E.D.

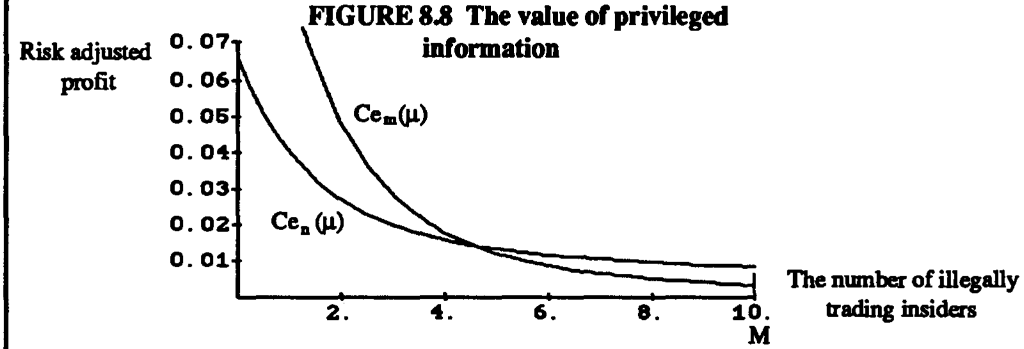
The value of superior information depends on the trade-off between expected profit and risk exposure where risk aversion determines the strength of the risk exposure. The Hirshleifer effect does not affect the welfare of the superiorly informed speculators because they are assumed to have no initial position (thus, $W_n = W_m = 0$ for all $n \in \{1, 2, ..., N\}$ and $m \in \{1, 2, ..., M\}$).

Proposition 8.15: *The value of superior information tends to decrease when the number of corporate insiders increases:*

(7.23) $$\frac{d\,Ce_n}{d\mu} < 0 \text{ and } \frac{d\,Ce_m}{d\mu} < 0.$$

Figure 8.8 illustrates.

FIGURE 8.8 The value of privileged information



In this example, $Ce^\bullet_m(\mu = 0) = 0.172 > Ce_m(\mu = 10) = 0.003 > Ce_m(\mu \rightarrow \infty) = 0$ and $Ce^\bullet_n(\mu = 0) = 0.066 > Ce_n(\mu = 10) = 0.008 > Ce_n(\mu \rightarrow \infty) = 0.004$. This means that if L changes exogenously from **A** to **B** where μ

$< M = 10$, the value of superior information is reduced. We observe that if $\mu < 4.768$, the value of inside information is greater than the value of privately acquired information before acquisition costs. Otherwise, $Ce_m(\mu) < Ce_n(\mu)$.

If the supply of corporate insiders increases, there are two additional effects relative to the ones identified in section 7.7 and summarized in tables 7.2 - 7.3. First, there is a reduction in the amount of uninformed trading because hedging is elastic, and, secondly, the bid ask spread is higher due to the market power of the intermediaries (and the eroding of market liquidity). These new effects influence both the expected profit and the risk exposure. The next table summarizes the major effects.

TABLE 8.3: Effects on welfare caused by $\Delta\mu$

$\Delta\mu$	ep	re	Total
$\mu = 0 \rightarrow \mu \leq M$:			
• Insiders	-	+	-
• Professionals	-	+	-

ep = expected profit and re = risk exposure.

Superiorly informed speculators lose welfare because the equilibrium bid ask spread increases and because they have less volume to hide behind. This means that even if the speculators are market professionals, the expected profit decreases monotonically. On the other hand, the effect on risk exposure is positive since insider trading reveals information and brings market prices nearer to their underlying fundamentals. In addition, the speculators` positions are reduced because of reduced hedging. However, the positive effect on risk exposure tends to be dominated by the negative effect on expected profit.

8.8 SHORT SUMMARY OF MAJOR CONCLUSIONS

Insider trading is analyzed in an environment with uninformed hedgers, two types of informed speculators, and market makers. I conclude that insider trading is not desirable because it reduces the amount of uninformed trading and thereby makers everybody (except elastic "liquidity traders") worse off. The stock market regulators should prohibit insider trading and enforce the law. This conclusion is strengthen if incentive effects are recognized; see chapters 5 - 6.

APPENDICES

This section is used to prove lemma 8.1 and to give the numerical values which are used to illustrate the equilibrium.

Appendix A Proof of lemma 8.1

The equilibrium price of security $k \in \{1, 2, ..., K\}$ at auction $t \in \{0, 1, ..., T_k - 1\}$ is determined by the market clearing condition:

$$\text{(A1)} \qquad \sum_{n=1}^{N} \tilde{\theta}_n + \sum_{m=1}^{M} \tilde{\Delta}_m + \sum_{h=1}^{H} \tilde{u}_h + \sum_{a=1}^{A} \tilde{\Lambda}_a + \sum_{q=1}^{Q} \tilde{\Theta}_q = 0.$$

Market clearing means that the demand of immediacy equals the supply of immediacy. I assume that the trading strategies of the suppliers of immediacy, who are the broker - arbitrageurs and the market makers, are linear in the market price. Thus,

$$\text{(A2)} \qquad \tilde{\Lambda}_a = -\psi\left(R\tilde{S} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right), \text{ and}$$

$$\text{(A3)} \qquad \tilde{\Theta}_q = -\upsilon\left(R\tilde{S} - E[\tilde{x} \mid \tilde{y}^* = y^*]\right),$$

respectively. I insert (A2) and (A3) into (A1), and yield the equilibrium price

$$\text{(A4)} \qquad \tilde{S} = \frac{1}{R}\left(E[\tilde{x} \mid \tilde{y}^* = y^*] + \lambda \tilde{z}\right),$$

where z is the market orders from the demanders of immediacy, which in this case are the informed speculators and the uninformed hedgers, and the price sensitivity

$$\text{(A5)} \qquad \lambda = \frac{1}{\sum_{a=1}^{A} \psi_a + \sum_{q=1}^{Q} \upsilon_q}.$$

If Q = 0, then (A5) equals (2.7.5). In this way, the market depth is provided by both arbitrageurs and market makers.

The risk adjusted profit of arbitrageur $a \in \{1, 2, ..., A\}$ is represented by the object function in their portfolio-selection problem given by (2.2). I insert the linear trading strategy given by (A2). Then the portfolio-selection problem of the broker - arbitrageur equals

$$\text{(A6)} \; \underset{\psi_a}{\text{Max}} \; - \psi_a \begin{pmatrix} R\tilde{S} - \\ E[\tilde{x} \mid \tilde{y}^* = y^*] \end{pmatrix} \begin{pmatrix} E[\tilde{x} \mid \tilde{z}, \tilde{y}^* = y^*] \\ - R\tilde{S} \end{pmatrix} - \frac{\rho_A}{2} \psi_a^2 \begin{pmatrix} R\tilde{S} - \\ E[\tilde{x} \mid \tilde{y}^* = y^*] \end{pmatrix}^2 \operatorname{var}(\tilde{x} \mid \tilde{z}, \tilde{y}^* = y^*).$$

The next step is to insert the price function given by (A4) and simultaneously take into account that from the arbitrageur`s perspective the price sensitivity is

$$\text{(A7)} \qquad \lambda = \frac{1}{(A - 1)\psi + \psi_a + Q\upsilon}.$$

In this way, the arbitrageur recognizes that he affects the market depth through his supply intensity ψ_a. After some straightforward simplifications, I yield

$$\text{(A8)} \; \underset{\psi_a}{\text{Max}} \; - \frac{\psi_a \tilde{z}^2}{(A - 1)\psi + \psi_a + Q\upsilon} \left\{ \frac{\operatorname{cov}(\tilde{x}, \tilde{z})}{\operatorname{var}(\tilde{z})} - \frac{1}{(A - 1)\psi + \psi_a + Q\upsilon} \left[1 - \frac{\rho_A}{2} \psi_a \operatorname{var}(\tilde{x} \mid \tilde{z}) \right] \right\}.$$

The first order condition gives the trading intensity

$$\text{(A9)} \qquad \psi = \frac{\Psi}{\rho_A + A\,as\,\Psi} \left\{ \frac{1}{mp_A} - Q\,\upsilon\,as \right\},$$

where $\mathbf{mp}_A$ is given by (3.14),

$$\text{(A10)} \qquad \mathbf{as} = \frac{\operatorname{cov}(\tilde{x}, \tilde{z} \mid \tilde{y}^* = y^*)}{\operatorname{var}(\tilde{z} \mid \tilde{y}^* = y^*)}, \text{ and}$$

$$\text{(A11)} \qquad \Psi = \frac{1}{\operatorname{var}(\tilde{x} \mid \tilde{z}, \tilde{y}^* = y^*)}.$$

The second order condition secures that the intensity determined by the first order condition is optimal, i.e., a maximum.

$$\text{(A12)} \qquad \mathbf{as} - \left(\frac{1}{A\,\psi + Q\,\upsilon}\right)^2 \left[\frac{(2\,A - 1)\,\psi + 2\,Q\,\upsilon}{(A - 1)\,\psi + Q\,\upsilon} + \frac{\rho_A}{2\,\Psi}\left[(A - 3)\,\psi + Q\,\upsilon\right]\right] < 0.$$

This suggests that $\psi \geq 0$.

In the same way, market maker $q \in \{1, 2, ..., Q\}$ determines his optimal supply intensity by solving his portfolio-selection problem parallel to (A6). The first order condition is

$$\text{(A13)} \qquad \upsilon = \frac{\Psi}{\rho_Q + Q\,\mathbf{as}\,\Psi}\left\{\frac{1}{\mathbf{mp}_Q} - A\,\psi\,\mathbf{as}\right\},$$

where $\mathbf{mp}_Q$ is given by (3.15). The second order condition is

$$\text{(A14)} \qquad \mathbf{as} - \left(\frac{1}{A\,\psi + Q\,\upsilon}\right)^2 \left[\frac{(2\,Q - 1)\,\upsilon + 2\,A\,\psi}{(Q - 1)\,\upsilon + A\,\psi} + \frac{\rho_Q}{2\,\Psi}\left[(Q - 3)\,\upsilon + A\,\psi\right]\right] < 0.$$

This suggests that $\upsilon \geq 0$.

I insert (A13) into (A9) and yield (3.9) after some straightforward calculations. Then I insert (3.9) into (A13) and yield (3.10). Finally, I insert (3.9) and (3.10) into (A5), and get the equilibrium price sensitivity given by (3.18) where as is given by (A10),

$$\text{(A15)} \qquad \text{mp} = \frac{A\,\rho_Q + Q\,\rho_A}{\rho_Q\,A\,\text{mp}_A + \rho_A\,Q\,\text{mp}_Q}, \text{ and}$$

$$\text{(A16)} \qquad \text{rc} = \frac{\rho_A\,\rho_Q}{\left(A\,\rho_Q + Q\,\rho_A\right)\Psi}.$$

I substitute (3.14) and (3.15) into (A15), and yield (3.19). Then I inset (6.1) into (A16), and yield (3.12), Finally, (3.16) follows from the structure of the securities market equilibrium in the same way as in earlier chapters.

The portfolio-selection problem of hedger h $\in$ {1, 2, ..., H} is given by (2.1). I use the price function given by (A4) and get this equivalent formulation of the hedger's problem.

$$\text{(A17)} \max_{\tilde{u}_h} \tilde{W}_h\,E[\tilde{x} \mid \tilde{y}^* = y^*] - \lambda\,\tilde{u}_h^2 - \frac{\rho_H}{2}\begin{bmatrix} \left(\tilde{W}_h + \tilde{u}_h\right)^2 \text{var}(\tilde{x} \mid \tilde{y}^* = y^*) + \lambda^2\,u_h^2\,\text{var}(\tilde{z} \mid \tilde{u}_h, \tilde{y}^* = y^*) \\ -\,2\,\lambda\left(\tilde{W}_h + \tilde{u}_h\right)\tilde{u}_h\,\text{cov}(\tilde{x}, \tilde{z} \mid \tilde{y}^* = y^*) \end{bmatrix}.$$

The first order condition gives the trading strategy given by (3.3) in which the trading intensity of the hedger equals

$$\text{(A18)} \qquad v = \frac{\rho_H\left[\text{var}(\tilde{x} \mid \tilde{y}^* = y^*) - \lambda\,\text{cov}(\tilde{x}, \tilde{z} \mid \tilde{y}^* = y^*)\right]}{2\,\lambda + \rho_H\left[\text{var}(\tilde{x} \mid \tilde{y}^* = y^*) + \lambda^2\,\text{var}(\tilde{z} \mid \tilde{u}_h, \tilde{y}^* = y^*) - 2\,\lambda\,\text{cov}(\tilde{x}, \tilde{z} \mid \tilde{y}^* = y^*)\right]}.$$

The trading intensity given by (3.8) follows directly. Finally, the second order condition follows from (A17), and equals

$$\text{(A19)} \qquad -\left[2\,\lambda + \rho_H\,\text{var}\!\left(\tilde{x} - R\,\tilde{S} \mid \tilde{u}_h, \tilde{y}^* = y^*\right)\right] < 0.$$

If $\rho_H \geq 0$ and $\lambda \geq 0$ (with at least one strict inequality), the second order condition is satisfied because the variance is always non-negative.

The portfolio-selection problems of the market professionals and the corporate insiders are given by (7.2.2) and (7.2.3) where the first order conditions are given by (7.3.1) and (7.3.2). These trading strategies are identical to the ones given by (3.1) and (3.2). The trading intensities are given by (7.3.3) and (7.3.4) which are identical to (3.6) and (3.7). The second order conditions for a maximum are given by (7.A2) and (7.A3). Finally, the variances given by (3.11) - (3.13) follow straightforwardly from the structure of the equilibrium. This completes the proof of lemma 8.1.

Appendix B Example

The following numerical values are used when drawing figures 8.1 - 8.8, illustrating the properties of the equilibrium:

TABLE 8.3:				**Numerical values**				
Γ	=	2	R	=	1	M	=	10
ε	=	2	ρ_M	=	1	μ	$\in$	$\{0, 1, ..., M\}$
η	=	1	ρ_N	=	1	N	=	2
ω	=	1	ρ_H	=	1	H	=	10
			ρ_A	=	1	A	=	2
			ρ_Q	=	2	Q	=	4

Note that the necessary "noise" from the hedgers is secured by increasing the size of their (limit) orders relative to the market order size of liquidity traders used in the previous chapter. In this example the difference between broker - arbitrageurs and market makers is that the broker - arbitrageurs are fewer but the market makers are more risk averse.

REFERENCES

Admati, A., and P. Pfleiderer, 1988, "Selling and Trading on Information in Financial Market," American Economic Review, 96 - 103.

Amihud, Y., and H. Mendelson, 1991, "How (not) to Integrate the European Capital Markets," Chapter 4 in A. Giovannini and C. Mayer, "European Financial Integration", Cambridge University Press, 73 - 100.

Bhattacharya, U., and M. Spiegel, 1991, "Insiders, Outsiders, and Market Breakdowns," Review of Financial Studies, 255 - 282.

Glosten, L. R., 1989, "Insider Trading, Liquidity, and the Role of the Monopolist Specialist," Journal of Business, 211 - 235.

Glosten, L. R., and P. R. Milgrom, 1985, "Bid, Ask and Transactions Prices in a Specialist Market with Heterogeneously Informed Traders," Journal of Financial Economics, 71 -100.

Grossman, S. J., 1981, "An Introduction to the Theory of Rational Expectations under Asymmetric Information," Review of Economic Studies, 541 - 559.

Grossman, S. J., and M. H. Miller, 1988, "Liquidity and Market Structure," Journal of Finance, 617 - 637.

Hirshleifer, J., 1971, "The Private and Social Value of Information and the Reward to Incentive Activity," American Economic Review, 561 - 574.

Holden, C. W., 1991, "A Theory of Arbitrage Trading in Financial Market Equilibrium," Discussion Paper # 478, Graduate School of Business, Indiana University.

King, M., and A. Röell, 1988, "Insider Trading, Economic Policy, 165 - 187.

Kyle, A. S., 1984, "Market Structure, Information, Futures Markets, and Price Formation," Chapter 2 in G. G. Storey, A. Schmitz, and A. H. Sarris (eds.) "International Agricultural Trade: Advanced Readings in Price Formation, Market Structure, and Price Instability, " Westview Press, 45 - 64.

Kyle, A. S., 1989, "Informed Speculation with Imperfect Competition," Review of Economic Studies, 317 - 355.

Leland, H. E., 1992, "Insider Trading: Should it be Prohibited?" Journal of Political Economy, 859 - 887.

Miller, M. H., 1991, "Financial Innovations and Market Volatility," Basil Blackwell.

Schwartz, R., 1988, "Equity Markets: Structure, Trading, and Performance," Harper and Row Publishers.

Spiegel, M., and A. Subrahmanyam, 1992, "Informed Speculation and Hedging in a Noncompetitive Securities Market," Review of Financial Studies, 307 - 329.

SYMBOL GLOSSARY

OF PART IV

(see also the symbol glossary of part II)

a	300
as	262, 304
A	300
β	261, 303
β^*	264
B	261, 303
B*	264
Ce	292
Ce_a, Ce_d, Ce_h, Ce_m, Ce_n, Ce_q	275, 277, 281, 284, 320, 321, 324, 328
d	259
D	259
Δ_m	258, 260, 303
ep, ep_m, ep_n	283, 286, 323
f( ), g( )	264
h	300
H	300
i	264
k	258
k`, k•, k••	287
K, K_t	258
λ	260, 261, 304
Λ_a	301, 303
m	258
mp	304
mp_A, mp_Q	304
μ`, μ``	317
μ_d, μ_β, μ_λ, μ_n	268, 272, 278, 285
M	258
n	257
ν	303
N	257
q	259
θ_n	258, 261, 302
Q	259
Θ_q	301, 303
rc	262, 304
re, re_d, re_m, re_n	279, 283, 286, 323
ρ	268, 288, 292

PART V

CONCLUSIONS

CHAPTER 9

SUMMARY OF MAJOR CONCLUSIONS

First draft: September 1992,

Current version: January 1993.

ABSTRACT

This chapter gives a short overview of the major conclusions in chapters 2 - 8. It is done by giving advice on how the stock market regulators, the various types of outsiders, and the corporate insiders should adjust to insider trading or its regulation.

9.1 INTRODUCTION

This dissertation focuses on insider trading regulations by analyzing rather formal financial market models in which the corporate insiders may differ in supply due to changes in the regulation of insider trading or its enforcement by the regulators. In chapter 2 - 8, the primary interest was what happens to the properties of the presented financial market equilibria, particularly the welfare of the various participants. The ensuing sections summarize by giving some advice to the financial market regulators, the various types of outsiders, and the corporate insiders based on the identified effects in my models.

9.2 ADVICE TO REGULATORS

If, for some reason, the financial market regulators want to protect small, uninformed investors, they should be aware that insider trading affects both production and exchange. This is because trading on inside information tends to decrease the adverse selection, the trading risk, the risk sharing possibilities, and the stability of the underlying fundamental. The two first effects are positive, whereas the two last are negative. Thus, the net effect may be negative or positive, depending on the market premises which, of course, may differ from exchange to exchange.

For instance, if a major part of the uninformed trading is motivated by hedging, the hedgers prefer insider trading prohibited because it decreases the possibility to share the risk associated with their initial positions. On the other hand, if a major part of the uninformed trading comes from unsophisticated traders whose trading often are motivated by liquidity events, these traders may prefer insider trading allowed because of the increased competition among the superiorly informed traders. This means that if the regulators want to protect small, uninformed investors, they have to find out what are the motives for trading. Regulations in financial markets should, of course, be based on a clear understanding of their effects combined with empirical analyses exploring the premises of the market. If the financial market regulators find it optimal to prohibit insider trading, they have to enforce the law and, consequently, take into account the cost of enforcement. Then the regulatory choices might be between allowing insider trading or prohibiting it by the support of an inadequate enforcement policy.

The problem with an inadequate enforcement is that the insiders are able to trade illegally either directly or indirectly by tippees. Obviously, this makes the choice of regulatory regime more difficult because the competition is reduced, giving the illegally trading insiders more market power. They respond by reducing their trading which at the same time gives them better camouflage and higher risk adjusted returns. My study also indicates that if the welfare of small, unsophisticated traders is the primary concern of regulators, prohibiting insider trading should in many cases be supported by adequate enforcement or else be allowed. This in turn suggests that the financial market regulators must implement operational rules (e.g., trading restrictions before announcements of major events) in order to eliminate illegal trading. Other considerations such as the managers` legal right to trade in their own stock based on "public" information must perhaps step aside some time before these events.

9.3 ADVICE TO OUTSIDERS

There are many types of outsiders such as liquidity traders, hedgers, market professionals, market makers, and broker - arbitrageurs. Normally, the market professionals would be better informed than the market makers and the broker - arbitrageurs. The hedgers and the liquidity traders, on the other hand, have only access to the history of the securities market, and are therefore less informed than the intermediaries and the superiorly informed speculators.

Liquidity traders

If a liquidity event occurs, the trader who is affected should trade in riskless assets such as bonds or in stock index futures where security-specific information is diversified away. Nevertheless, if these liquidity traders have to sell stocks they already own, they should choose to sell at a time where the informed trading is expected to have small impact on the trading cost; for instance, just after the company has published information. Other strategies are also possible, but difficult in practice, because the discretionary liquidity traders then need much information about market conditions.

Hedgers

If the corporate insiders are allowed to trade, the effectiveness of hedging strategies by taking offsetting positions in the spot market tends to be reduced because of reduced and even destroyed risk sharing opportunities. This means that hedgers operating on an exchange characterized by insider trading should think somewhat differently about hedging, because it becomes more important to always hold diversified portfolios. As we know, diversification eliminates the security-specific risk leaving the hedgers only with non-diversifiable risk which have to be borne by someone. If the hedgers always see to it that they hold diversified portfolios, they are only hurt by informed traders who have access to information about the systematic component in the return of their portfolio.

Market professionals

Securities analysts and other quasi-insiders should concentrate their effort on securities where there is minimal competition from real insiders. In this way, their supply will be elastic in the number of corporate insiders which may also improve the terms of trade for uninformed such as hedgers and liquidity traders. If the professionals are concerned about the risk of trading, insider trading would hurt them less. This is because informed trading brings the prices closer to their fundamentals.

Market makers and broker - arbitrageurs

Dealing in securities characterized by insider trading is disadvantageous unless the dealer holds a low inventory or is concerned about the risk of trading. This means that the exchange members usually are demanders of regulation, and because there often is a close relation between the exchange and the control authorities, these demanders are often heard.

9.4 ADVICE TO INSIDERS

We have seen that corporate insiders and their tippees outside the firm may trade illegally by hiding behind outsiders in the net flow of orders. But as long as the law is enforced, there is a positive probability that the insiders are identified and punished according to the law. Of course, illegal trading is not recommended. Nevertheless, traders possessing inside information may easily develop trading strategies which is hard to pursue by the control authorities. For instance, if the insiders exploit the fact that information is correlated, the risk of detection is small. If one of company A`s insiders receives information revealing that A is undervalued, a profitable strategy might be for the insider`s tippee to buy stocks in company B which is in the same industry. Corporate insiders can also take advantage of their information by not trading. If, for instance, the insiders observe good news, they can either buy stock or postpone previously planned sales until after the news is revealed in the market price.

9.5 FUTURE RESEARCH

I have shown that the effects of insider trading may depend on the parameters of the model, leading to different conclusion for different sets of parameters. This suggests that future research should be more empirical in the sense that insider trading should be analyzed separately on every exchange. Perhaps the law should be adjusted to take into account potential differences in market characteristics such as the elasticity of the liquidity demand. Theoretical research should continue to focus on insider trading in market designs close to the ones actually observed. This in order to improve our understanding of the basic underlying effects caused by insider trading and its regulation.