THE EFFECTS OF REGULATORY CHANGES ON INSIDER TRADING AND PRICE MOVEMENTS DURING CORPORATE TAKEOVERS

by

ZHU STUART LIU

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M.A. Carleton University, 1987

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Abstract

This thesis addresses two important issues necessary to understand whether insider trading should be prohibited: the effects of insider trading on stock prices and the compensation to insiders for providing information and other related services. This task is accomplished by analyzing stock price changes during corporate takeovers, before and after the regulatory changes in the 1980's that were designed to reduce the level of insider trading.

In this thesis, we develop an indirect measure of insider trading that shows how observable stock price movements during takeovers allow one to make inferences about changes in insider trading after regulatory changes. Specifically, we show that when inside information is partially revealed to the market, the effects of regulatory changes on insider trading can be identified by examining the price movements of stocks around takeover announcements. If, however, information is not revealed at all or is fully revealed, it is impossible to identify the effects of regulatory changes on insider trading.

We also develop a segmented diffusion model to analyze price movements characterized by cumulative abnormal returns during the period surrounding a takeover announcement. An econometric model is developed to estimate the segmented diffusion model. Naturally, this methodology applies to the study of various events in addition to corporate takeovers and regulatory changes.

We conduct empirical analysis to test three hypotheses. With regard to Hypothesis I, we find strong evidence that the tightening of insider trading regulations in the 1980's was effective and that inside information was partially revealed to the market. With regard to Hypothesis II, we find evidence that insider trading regulations have more effect on negotiated takeovers than on takeovers initiated by bidding. With regard to Hypothesis III, we find weak evidence that insiders associated with acquiring firms seek fewer but more profitable takeovers after the introduction of tighter regulations.

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Chapter One

INTRODUCTION

1.1 Overview

Recent debate on insider trading has questioned the social consequences of insider trading and the role of insider trading regulations. Undoubtedly, there are instances in which insider trading misappropriates returns to insiders.[1] Partially in response to concerns regarding the negative distributional effects of insider trading, the 1980's witnessed a series of attempts to strengthen insider trading regulations. Nonetheless, recent theoretical research has shown that there might be instances in which insider trading provides social benefits that outweigh social costs. It is crucial to know, therefore, under what circumstances insider trading should be prohibited and, if so, how to achieve it without losses of economic efficiency. In order to provide a satisfactory answer to these questions, many complicated issues need to be analyzed carefully on both theoretical and empirical grounds. This thesis addresses two important issues necessary to the understanding of the above questions: the effects of insider trading on stock prices and the compensation to insiders for providing information and other related services. This task is accomplished by analyzing stock price changes during corporate takeovers, before and after the regulatory changes in the 1980's that were designed to

[1] For example, in a series of cases against Dennis Levine and Ivan Boesky involving insider trading, the damages incurred by insider trading are apparent. Beginning in May 1986 the Securities and Exchange Commission (SEC) filed a series of civil complaints against several Wall Street insiders in the United States District Court for the Southern District of New York. The central figure among these cases is Dennis Levine, a managing director of Drexel Burnham Lambert, Inc. The SEC complaint against Levine alleged that he reaped $12.6 million in profits trading in the shares of 54 companies over more than five years, on the basis of nonpublic information concerning possible mergers, tender offers, leveraged buy-outs, recapitalizations, and other extraordinary corporate transactions. Levine often learned of these impending transactions as the investment banker representing one of the corporations involved. The SEC complaint against Boesky alleged that he traded on the basis of information tipped to him by Levine. Levine settled with the SEC surrendering $11.6 million in profits and receiving two years in prison. Boesky settled with the SEC returning $50 million in profits and paying another $50 million as a civil penalty.

reduce the level of insider trading.

This chapter contains nine sections. Section 1.2 discusses the relevance of the two issues addressed in this thesis to the theoretical questions of when and how to regulate insider trading. Section 1.3 discusses the relationship among insider trading, information revelation and economic efficiency. Section 1.4 elaborates on the problem of insiders' compensation in the case of corporate takeovers. Section 1.5 reviews the development of insider trading regulations in the U.S. Section 1.6 focuses on the distinction between legal insider trading and illegal insider trading. Section 1.7 reviews the previous literature concerning the effects of changes in insider trading regulations. Section 1.8 outlines the research design. Finally, section 1.9 lays out the structure of the thesis.

1.2 Theoretical Motivations

The seminal work by Manne (1966) is among the first to recognize that, while certain types of insider trading could be harmful, the overall effect of insider trading should be examined in conjunction with stock market efficiency and compensation to "entrepreneurs". He noticed that trading by insiders with superior information may lead to more informationally efficient stock prices, which in turn leads to more efficient capital allocation. Moreover, he argued that insider trading profits can be viewed as compensation for the services provided by insiders, including the service of providing inside information, when other forms of compensation fail to motivate insiders to perform these services. Unless such benefits of insider trading are considered, analysis leading to rules against insider trading is incomplete.

The advance in theory since Manne (1966) has revealed that the relationship between insider trading and stock market efficiency is complex. While, in general, it is found that insider trading leads to more informational efficient stock prices (Kyle (1985), Glosten (1989), Leland (1992)), some models demonstrate that this is not always the case. Laffont and Maskin (1992), for example, show that with imperfect competitive market, insiders are able to behave strategically to conceal their superior information, therefore insider trading may not reveal any inside information to the market. Alternatively, Fishman and Hagerty (1992) show that although inside information is revealed in the prices, insider trading does not necessarily lead to more efficient stock prices, as insider trading deters other traders from acquiring information. Thus, the question whether and when insider trading leads to more efficient stock prices needs empirical analysis.

The issue of compensation to insiders links insider trading directly with other corporate activities. One implicit argument put forward by Hirshleifer (1971) maintains that if inside information generates social value, then insiders should be compensated fairly, otherwise undercompensation leads to the loss of social value. The argument by Manne (1966) and Carlton and Fischel (1983) implies that if, in addition, inside information is a by-product of other productive corporate activities, compensation to insiders should reflect the value of other productive corporate activities in addition to the value of inside information per se. When other forms of compensation cannot serve the purpose of compensation, insider trading may be an effective means. Compensation to insiders has been studied in the context of various corporate events.[2] We consider in this thesis the particular case of compensation to insiders associated with corporate takeovers.

1.3 Insider Trading, Information Revelation and Stock Prices

The question whether insider trading leads to more efficient stock prices has immediate implications on how best to regulate insider trading. Unfortunately, there is no agreement on this subject matter. On one hand, some argue that informational efficiency leads to investment efficiency,

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[2] Some recent models analyze explicitly or implicitly the compensation problem of insiders along with other corporate decisions. For example, Kyle and Vila (1991) address insiders' compensation during takeovers. Fishman and Hagerty (1992) address insiders' compensation together with production decision. Bernardo (1993), Fischer (1992) and Giammarino, Heinkel and Hollifield (1994) address insiders' compensation together with investment decision.

which is socially beneficial (e.g., Carlton and Fischel (1983)). On the other hand, others demonstrate that even if insider trading leads to a more informational efficient stock market, society as a whole may still not benefit from insider trading. For example, Manove (1989) shows that insider trading deters outside investors from participating in the stock market and the deterrence effect in turn discourages corporate investment. Bhattacharya and Spiegel (1991) show that, in the extreme, the adverse selection leads to the collapse of the stock market. Fischer (1992) shows that insider trading encourages managers to undertake inefficient investment projects thus creating a moral hazard problem. In contrast, Leland (1992) shows that, in slightly different circumstances, informational efficiency always enhances investment efficiency. However, the overall efficiency depends on whether the gains from greater investment efficiency outweigh the costs of insider trading, measured by losses to outsiders over gains to insiders. Many of these arguments require empirical justification which is not available. In this thesis we address specifically the question whether insider information leads to more efficient stock prices. This is an important step towards the more complicated assessment of economic efficiency of insider trading.

1.4 Insider Trading and Corporate Takeovers

Most insider trading violations are related to corporate takeovers. Meulbroek (1992) examines all insider trading cases charged by the Securities and Exchange Commission (SEC) in civil or administrative cases during 1980-1989.[3] According to her, among the 183 insider trading cases that occurred during this period, 145 (79%) are takeover related (of which 39% are tender offers, 29% are mergers, 5% are leveraged buy-outs, 2% are restructurings and 2% are major share acquisitions). Insider trading related to other corporate events includes earnings (8%), Bankruptcy or financial fraud (5%) and miscellaneous news (7%). Different corporate events are likely to have

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[3] Meulbroek (1992) is among a few who studies *illegal* insider trading based on detected insider trading cases.

different degrees of insider trading and different stock price effects. Therefore it is important to separate insider trading cases according to the nature of the underlying event. In this thesis, we choose to study only corporate takeovers to narrow the scope and, at the same time, to focus on the event where insider trading is most likely to show up.

The reason insider trading occurs more frequently during takeovers is perhaps due to the large profits created by takeovers. Empirical evidence confirms consistently that the total gains from takeovers are on average positive. Furthermore, while there is no agreement whether acquiring firms benefit from the takeover, the value gain to the target firm during the takeover event period is found to be somewhere between 10-50 per cent.[4]

One puzzling phenomenon associated with takeovers, especially in tender offers, is that the bidder seems to incur all the costs of undertaking a takeover, while the target enjoys all the benefits.[5] If this were indeed the case, then takeovers should never occur. Grossman and Hart (1980) suggest that the "dilution effect" may allow the bidder to be compensated with a substantial portion of the takeover profit. For instance, suppose a bidder gains control over a target through a takeover. The bidder could sell later some of the businesses taken over earlier to another firm owned by itself at a low price, therefore recapturing part of the takeover profit.[6] While Grossman-

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[4] Evidence includes Dodd and Ruback (1977), Kummer and Hoffmeister (1978), Dodd (1980), Jarrell and Bradley (1980), Keown and Pinkerton (1981), Bradley, Desai and Kim (1982,1983,1988), Asquith and Kim (1982), Asquith (1983), Eckbo (1983), Malatesta (1983), Frank and Harris (1985), Jarrell and Poulsen (1989), Nathan and O'Keefe (1989), Lang, Stulz and Walkling (1989) and Stulz, Walkling and Song (1990).

[5] For some discussions on this, see, for example, Dodd and Ruback (1977), Asquith (1983), Roll (1986), Bradley, Desai and Kim (1988) and Jarrell, Brickley and Netter (1988).

[6] There are some evidence that supports this view. Porter (1987), Ravenscraft and Scherer (1987) and Kaplan and Weisbach (1992) estimate that about 30-50% of mergers and acquisitions between the 1960s and early 1980s are divested later. Kaplan and Weisbach (1992) studied 119 divestures between 1971-1989 which are bought on average seven years ago from acquisitions. Among 119 divestures, 43% are sold due to change of business focus or strategy, 29% are sold to finance the initial acquisitions. In particular, 22% are sold to the management. The average return from the divesture, relative to the price bought initially, deflated by S&P 500 index is -11%, although average performance of the divested firms do not exhibit accounting gain or loss (44% with loss on sale and 56% with gain or no loss on sale).

Hart's dilution effect explains part of the bidder's compensation, it is far from complete. Shleifer and Vishny (1986) offer an alternative explanation. They point out that a large incumbent shareholder of the target may have the incentive to engage in a takeover, as the value of their stake in the target could be improved greatly. Their theory may explain bidder's compensation when the takeover involves the acquisition of the remaining stake the bidder previously did not own. Kyle and Vila (1991) advance the Grossman-Hart and Shleifer-Vishny theories by introducing insider trading into bidder's compensation. They model the insider as a large trader who decides whether or not to take over a target, depending on how much inside trading profit he gets. Unless the insider obtains a large enough profit from pre-takeover trading to cover the costs of engaging in the takeover, the takeover will not occur.[7]

The above discussion shows that there appear to be situations in which legal compensation to the bidder, often the major insider, is insufficient to justify the presence of the takeover. In this thesis we attempt to identify whether some compensation is obtained by insiders through illegal trading. If insider trading is motivated by the reason advanced by Kyle-Vila, the insider trading gains must increase for successful takeovers as the costs of takeover increase. In addition, as the tightening of insider trading regulations reflects a higher cost of insider trading during takeovers, tightened regulations increase the overall costs of takeovers of the insiders. Therefore, when

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[7] In addition to the theories mentioned above, there are other theories explain bidder's compensation. For example, Bagnoli and Lipman (1988) and Holmstrom and Nalebuff (1992) point out that the uneven distribution of target share ownership may overcome the free-rider problem which gives the raider the incentive of launching a takeover. These theories predict that the abnormal returns to the bidder during takeovers are comparable with those to the target, which is, in general, not the case on the basis of empirical observation. Another class of models based on asymmetric information structure between the bidder and the target also explain some of the bidder's compensation. Giammarino and Heinkel (1986), Fishman (1988), Hirshleifer and Png (1989) and Hirshleifer and Titman (1990) show that, because the bidder is better informed than the target about the true gains from the takeover, the bidder can extract part of the gains from the takeover as information rent. These models explain only those takeovers during which the bidding firms experience positive abnormal returns. Empirical evidence on whether the bidding firm enjoys positive abnormal returns during takeovers is, however, mixed. For some relevant discussion on this issue, see, for example, Asquith, Bruner and Mullins (1983), Dodd (1980), Eckbo (1983), Jarrell, Brickley and Netter (1988), Jensen and Ruback (1983), Malatesta (1983), Roll (1986) and Schipper and Thompson (1983).

regulations become more strict, insiders as acquirers would seek, on average, more profitable takeovers, in effect, "truncating" the distribution of the takeovers that would actually occur. If this is indeed the case, we will observe the same "truncation effect" hypothesized by Jensen and Ruback (1983).[8] The "truncation effect" allows us to investigate empirically the issue of insiders' compensation associated with takeovers.

1.5 Insider Trading Regulations

As we have already indicated, the empirical analysis in this thesis relies on the impact of regulatory change on insider trading. In this section, we provide an historical review of the changes in U.S. regulations as background for our study.

The Securities and Exchange Act of 1934 regulated insider trading in the U.S. for the first time. The 1934 Act requires insiders to disclose material inside information or refrain from trading. Sections 10(b) of the 1934 Act prohibits trading based on material, non-public information. Section 14(e) provides antifraud provisions. Section 16(a) requires insiders to report their transactions to the SEC. Section 16(b) restricts short-swing profits. Section 16(c) prohibits short sales. Section 32 provides civil and criminal penalties against the violation of securities laws.

In conjunction with the 1934 Act, the Williams Act of 1968 and its Amendments of 1970 regulate tender offers. Sections 13(d) and 14(d) of the Williams Act require disclosure of tender offers of both public and private offers. The Amendments of 1970 broaden the disclosure requirements in the Williams Act.

Rule 10(b)-5 and 14(e)-3 of the Securities and Exchange Act of 1934 implement the regulations. Section 16(a) of the 1934 Act defines corporate officers, directors, and holders of more

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[8] Jensen and Ruback (1983) discussed the "truncation effect" in the context of regulations of tender offers. The basic argument of the hypothesis is that regulations increase the costs of takeovers.

than 10 per cent of any equity class of securities as corporate insiders and requires them to report transactions to the SEC within ten days after the end of the month of trading. Section 10(b) of 1934 Act further broaden the concept of insiders to include anyone who obtains material, non-public information from a corporate insider, or from the issuer, or who steals such information from another source. The Williams Act Amendments further specifies that anyone who is involved in the tender offer that leaves the offeror over 5 per cent of outstanding securities in its class is considered an insider and requires the insider to file a Schedule 13D before launching to the tender offer. In this thesis, insiders' transactions that do not violate the current regulations are deemed to be legal insider trading transaction and those prohibited by the regulations are deemed to be illegal insider trading transaction.

Over the decade of the 1980s, several provisions were enacted that were designed to improve compliance with insider trading regulations. In August 1984, the Congress passed the Insider Trading Sanction Act of 1984 (ITSA). ITSA provides for up to three times the insiders' illegal profits in civil penalties and a tenfold increase in criminal penalties from a maximum fine of $10,000 to $100,000. In November 1988, the Congress passed the Insider Trading and Securities Fraud Enforcement Act (ITSFEA). ITSFEA created the concept of "controlling person", thereby holding top management responsible for failure to comply with insider trading regulation by any employees of the firm. It also increased the maximum jail sentence to ten years and maximum criminal penalties to $1 million from $100,000.

While new legislation increased the penalties for violation of the insider trading regulations, SEC enforcement also became more strict. In 1981, led by its new chairman John Shad the SEC intensified its enforcement efforts. From January 22, 1982, to August 29, 1986, the SEC initiated 79 10(b)-5 cases against insider trading, an average 17.2 per year, which is more than a sixfold increase in the rate of prosecution against insider trading compared to the previous period.[9] From July, 1986 to December, 1987, the SEC initiated 42 10(b)-5 cases, an average 29 cases per year, which represents a 68.6 per cent increase in the rate of legal cases relative to the 1982-1986 period.[10] As a result, the number of insider trading violations detected by the SEC has declined form an average of 25.0 episodes per year for the period of 1982-1984 to an average of 10.3 episodes per year for the period of 1986-1988.[11]

The passage of ITSA and ITSFEA along with the increased enforcement can be viewed as landmark shifts in the regulatory environment (i.e., in this thesis, the term regulatory changes includes both regulation changes and enforcement changes). We can clearly identify three regulatory regimes: (1) prior to 1985, a regime of lax regulations; (2) between 1985 and 1988, a period of transition characterized by a gradual increase in efforts to improve regulation compliance; and (3) since 1989, a regime of tight regulations. In our empirical work we will compare price movements during takeovers between the first regime and the third regime.

1.6 Illegal Insider Trading

This thesis concerns illegal insider trading which we have defined above as trading prohibited by the current insider trading regulations. As we also showed above, regulations on insider trading have been reasonably consistent concerning the definition of illegal insider trading. New regulations mostly made the previous definitions on what is illegal insider trading more explicit, or increased the penalty on insider trading violation. In subsequent chapters, when we refer to insider trading, we will mean *illegal* insider trading.

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[9] See Haddock and Macey (1987).

[10] See Levine and Mathews (1987).

[11] See Meulbroek (1992), table I.

Empirical studies of insider trading generally pertain to transactions reported to the SEC as insider trading.[12] Most of these reported transactions do not appear to be associated with any illegal insider trading. For example, Seyhun (1992a) investigated insider trading based on the Official Summary of Insider Trading between 1975-1989. He started with a sample of 19,571 firms with 844,399 insider trading transactions between 1975-1989. From this sample, 8,856 firms (roughly about 45 per cent of the overall sample) had sufficient data for his purpose, which suggests the data he used contains approximate 379,000 insider trading transactions. In contrast, Meulbroek (1992a) reported that during the period 1980-1989 only 183 insider trading cases were charged by the SEC. The comparison of these numbers suggests that only a small fraction of insider trading transactions in Seyhun's sample violated the insider trading regulations.

1.7 Previous Research on Insider Trading Regulations

There is a large literature on the profitability of insider trading. However, only a few studies investigate the effects of insider trading regulations. Jaffe (1974a) studied the effects of strengthening insider trading regulations that occurred between 1961-1966. He analyzed the effects of regulatory change by comparing insider trading profits in five different regulatory regimes over the years 1961-1967. Based on the Official Summary of Insider Trading (the Summary), a report published by the Securities and Exchange Commission on transactions executed by corporate officers,

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[12] There is a vast literature study the profitability of insider trading based on transactions reported by corporate officers to the Securities and Exchange Commission. Lorie and Niederhoffer (1968), Jaffe (1974a, 1974b), Finnerty (1976a, 1976b), Elliott, Morse and Richardson (1984), Givoly and Palmon (1985), Seyhun (1986,1988, 1992a, 1992b), Heinkel and Kraus (1987), Rozeff and Zaman (1988), Lin and Howe (1990), and Chowdhury, Howe and Lin (1993) study aggregate insider purchases and sales. Basel and Stein (1979) study insiders' purchases and sales for Canadian Banking Industry. Penman (1982, 1985) studies insider trading around earnings forecast announcement. John and Lang (1991) study insider trading around dividend announcement. Sanders and Zdanowicz (1992) study insider trading around a proxy fight. Gosnell, Keown and Pinkerton (1981) study insider trading around bankruptcy announcement. Lee, Mikkelson and Partch (1992) study insider trading around stock repurchases.

directors and owners of ten per cent or more of the common stock of the firms traded publicly, he examined the average abnormal returns of the securities involved in insider trading during periods when insiders traded. He found no statistically significant difference among the different regulatory regimes, and concluded that regulatory changes had no effects over the period he studied. Seyhun (1992a) extended Jaffe's method by examining both insider trading profitability and volume. He investigated insider trading based on "the Summary" between 1975-1989. Although a series of efforts to strengthen insider trading regulations were made during this period, he found no significant changes on insider trading profitability and volume.

The "no effect" result found in these studies is perhaps due to the choice of the sample. As we showed, only a small fraction of the transactions reported by "the Summary" can be considered as illegal insider trading. In this thesis, we focus on illegal insider trading and do not rely on "the Summary" for sample construction.

1.8 Research Design

In general, there are two alternative approaches to the analysis of insider trading in empirical studies. The first one is a direct approach in which the effects of regulatory change are examined by comparing regulated activities before and after the regulatory change. In this approach, insider trading activities are either captured by reported transactions of insiders (Jaffe (1974a) and Seyhun (1992a)), or are detected by illegal insider trading cases (Jarrell and Poulsen (1989) and Meulbroek (1992)). However, reported insider trading transactions do not serve our purpose of analyzing the impact of regulations on *illegal* insider trading. At the same time, illegal insider trading activities detected from insider trading cases might be biased.[13] Therefore we do not use the direct approach.

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[13] Jarrell and Poulsen (1989), for example, study the effects of illegal insider trading on the price run-up prior to the takeover announcement by comparing takeovers involved in detected insider trading allegations with other takeovers. They find that illegal insider trading explains a little of pre-takeover price run-up. They

In this thesis, we adopt an indirect approach to examine the effect of regulatory change on illegal insider trading. Here we do not need to know explicitly who are the insiders. Instead, we look at stock price responses to takeover announcements before and after change in insider trading regulations. If insider trading has a predictable effect on market prices, then a change in insider trading activity due to an effective change of regulations will lead to a change in market price in the anticipated direction. As the change in market price and the change in regulatory environment is observable, we can then make inferences about the effectiveness of the changes of insider trading regulations.

Our indirect approach analyzes market price changes during corporate takeovers. Evidence reveals that there is a substantial price run-up associated with the target stock prior to the takeover announcement up to nearly 50 percent of the total capitalized value of the takeover event.[14] Keown and Pinkerton (1981) conclude that the price run-up is due to information leakage and insider trading associated with the impending takeover. Jensen and Ruback (1983) dispute that pre-takeover price run-up is possibly due to a series of occurrences related to the impending takeover before the takeover announcement. Jarrell and Poulsen (1989) show that a large fraction of the pre-announcement price run-up is due to press speculation and inaccurate identification of the actual takeover announcement. Meulbroek (1992) further noticed that, based on the 185 insider trading charged by the SEC, 43% of the pre-announcement price run-up is due to illegal insider trading.

As pre-announcement price run-up may be attributed to factors other than insider trading, we employ a particular research design to filter out other effects as much as possible. In this design,

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suspect the result is influenced by undetected illegal insider trading involved in other takeovers. In contrast, Meulbroek (1992), using a different approach, finds that illegal insider trading is the major source of pre-takeover price run-up.

[14] See, for example, Dodd and Ruback (1977), Dodd (1980), Keown and Pinkerton (1981), Asquith (1983), Bradley, Desai and Kim (1988) and Jarrell and Poulsen (1989).

we compare the effects of aggregate trading activities on the market in two distinct regulatory regimes (a regime of lax regulation, prior to 1985, and a regime of tight regulation, since 1989). We focus on differences in market response characteristics that are not likely to change significantly over time and thus can attribute the observed impacts to changes in the regulatory environment. Since the specific changes observed in insider trading regulations should not affect legal insider trading or other factors, such as press speculation, any change in the aggregate trading activities should then reflect the change of illegal insider trading activity in response to the changes in the regulations.[15]

1.9 Organization of the Thesis

This thesis contains five chapters. Chapter 2 is devoted to the modelling of the impact of regulatory change on price movements during takeovers. We first develop a model of indirect measure of the change of insider trading in response to the regulatory change. Next, we introduce a segmented diffusion process to model the cumulative abnormal returns during the period around the announcement time. The model consists of two simultaneous segmented stochastic equations. A stochastic differential equation models the cumulative abnormal returns during two different time segments, one for the period prior to the announcement, and another for the period including and following the announcement. The solution to this segmented stochastic differential equation provides two additional time segments that can also be incorporated into the estimation process. The model contains five parameters, reflecting the total cumulative abnormal returns, the price run-up prior to the takeover announcement, the price run-up at the takeover announcement, the rate of price run-up before the announcement, and the rate of price run-up after the announcement.

[15] But constraints about prosecution and other transaction costs associated with tighter regulations may have some effects which may not be filtered out by our research design.

Chapter 2 also discusses several implications of the two models. The implications can be tested in three hypotheses. First, based on our analysis on information revelation that identifies the relationship among regulatory change, insider trading and its stock price effects, we construct Hypothesis I which states that inside information is partially revealed to the market and the tightening of insider trading regulations in the 1980's is effective. Secondly, we argue that, on one hand, negotiated takeovers are more vulnerable to information leakage; on the other hand, the takeover process for negotiated takeovers is more vulnerable to regulations because, in the case of takeovers initiated by bidding, insiders are more flexible in substituting illegal trades with legal trades. Therefore, we put forward Hypothesis II which states that the impact of regulatory change is greater on the negotiated takeover than on the takeovers initiated by bidding. Finally, we analyze how insiders are compensated for their forgoing insider trading profit when regulations become more strict, in the line of the Kyle-Vila model. Hypothesis III states that insiders seek more profitable takeovers after regulations become tighter, and this effect is stronger for negotiated takeovers than for takeovers initiated by bidding. These three hypotheses are characterized by the parameters of the segmented diffusion model.

Chapter 3 develops the econometric model for the estimation of the segmented diffusion model. The model is well defined for a wide range of parameters. Estimation is based on non-linear full information maximum likelihood method. Our method is easy to apply because the objective function for the maximum likelihood estimation can be simplified into the sum of squared terms.

Using the pattern of the cumulative abnormal returns to analyze the price effect of an event appeared first in Fama, Fisher, Jensen and Roll (1969). While this method provides useful information about the price movements during a event period, until recently there were no statistical model incorporated into the analysis of the cumulative abnormal returns. Boardman, Vertinsky and Whistler (1992) introduce non-linear regression analysis into this approach making it possible to carry out statistical analysis of the pattern of the cumulative abnormal returns. The Boardman-Vertinsky-Whistler (BVW) method, however, is limited to certain types of price reactions to the event. It may encounter two kinds of estimation problems associated with the non-linear structure of the model to be estimated: an underestimation problem and an identification problem. The segmented diffusion model overcomes both problems encountered in BVW.

Chapter 3 also includes some discussion about the properties of the estimates, the comparison of the segmented diffusion model with other event study methodologies and the applications of the segmented diffusion model as a general event study model. In contrast with other methods of event studies, the segmented diffusion model has advantages in dealing with time-varying capitalization processes and is robust in estimating non-linear specification of capitalization processes. This segmented diffusion model is in general applicable to event studies of various type of events and is the basis for our empirical analysis.

Chapter 4 applies the models developed in the earlier chapters to conduct an empirical analysis on sample construction, data preparation and results of hypothesis testing. In the empirical analysis, we compare the effects of aggregate trading activities on the market including both legal and illegal trades in two distinct regulatory regimes to make inferences on changes in illegal trades. We refer to the period 1982-1984 as a lax regulated period and the period 1988-1991 as a tightly regulated period. We then selected six industries that are most active in corporate takeovers in these two periods to construct four samples of takeover targets: negotiated takeovers and takeovers initiated by bidding, one for each regulatory regime. Several criteria are imposed in the selection of target firms in order to control for other impacts associated with stock price movements. These criteria include the process of how the deal is conducted, the size of the transaction, the interplay between the acquirer and the acquiree, and the success of the takeover attempt.

The empirical results we found can be summarized as follows. With regard to Hypothesis

I, we find that the regulatory change in the 1980's are effective and that insider trading reveals inside information partially to the market. The findings concerning the effectiveness of the regulatory changes in the 1980's is in strong contrast with the earlier result by Jaffe (1974a), and especially Seyhun (1992a). We tend to attribute the differences to our more appropriate research design. The result concerning partial revelation is consistent with previous work by various studies including Meulbroek (1992). With regard to Hypothesis II, we find that insider trading regulations have more effect on negotiated takeovers than on takeovers initiated by bidding. This evidence supports our conjecture that in the case of takeovers initiated by bidding, inside information is a better kept secret and insiders have more flexibility to substitute illegal trades with legal trades due to their control of the timing of trades and the takeover declaration. With regard to Hypothesis III, we find some evidence of the "truncation effect" and a shift to more profitable takeovers occurring to market. However, when comparing this evidence with results for the above two hypotheses, it appears that the interpretation as the truncation effect should be made with caution, although the evidence seems to suggest that insider trading profit might be a means of compensation for undertaking the takeover project.

Finally, Chapter 5 summarizes the thesis and discusses potential future research.

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Chapter Two

MODELLING THE EFFECTS OF REGULATORY CHANGES ON PRICE MOVEMENTS

2.1 Introduction

This chapter is devoted to the modelling of the impact of regulatory change on stock price movements during takeovers. Empirical research on the effect of regulatory change often takes a direct approach using either reported insider trading transactions or detected insider trading cases. However, as illegal insider trading is not always detected, this approach has its limitations. Instead, we adopt an indirect approach to study the regulatory effects on illegal insider trading. This indirect approach does not require explicitly knowledge of who are those insiders; instead, it depends on observed regulatory changes and observed price movements to make inferences on insider trading.

The indirect approach relies on the relationship between regulatory change and insider trading, and the relationship between insider trading and its effects on stock prices. Meaningful inferences on insider trading depend on the extent to which the market reveals inside information through price adjustments. Theory on information revelation suggest that inside information may or may not be revealed to the market through trading, depending on the economic environment characterized by market characteristics, agent characteristics and other economic factors. Different economic environments reflected by different types of information revelation will produce different price effects when insider trading activity is present. In this chapter, we analyze the consequences of three equilibria that emerge from various economic environments: a fully revealing equilibrium, a partially revealing equilibrium and a non-revealing equilibrium. We develop a model that allows us to make inferences about the effects of regulatory changes on insider trading under different degrees of information revelation through analyzing price movements during takeovers. Our model suggests that when inside information is partially revealed to the market, the effects of regulatory changes on insider trading can be inferred by examining price movements. However, if information is not revealed at all or is fully revealed, it is impossible to access the effects of regulatory change on insider trading.

Empirical analysis of the price effect of regulatory change requires a dynamic specification of price movements. In this chapter, we also employ a segmented diffusion process to analyze the cumulative abnormal returns during corporate takeovers. The segmented diffusion process consists of two different time segments, one for the period prior to but not including the announcement, and another for the period including and following the announcement. The solution to this segmented stochastic differential equation provides also two different time segments. The process is characterized by five parameters that reflect the total cumulative abnormal returns, the price run-up prior but not including the takeover announcement, the price run-up prior and including the announcement, the rate of price run-up before the announcement, and the rate of price run-up after the announcement.

When insider trading is reflected in the price movements, the price response to the change of insider trading is captured by changes in the parameters of the segmented diffusion model. Consequently, we are able to test hypotheses concerning the nature of information revelation, the effect of regulatory change and the differences among different types of takeovers by examining the model's parameters. In this chapter, we construct three hypotheses. Hypothesis I deals jointly with information revelation and the effectiveness of regulatory changes. Hypothesis II concerns whether the regulatory changes had more impact on insider trading during negotiated takeovers than on insider trading during takeovers initiated by bidding. Hypothesis III deals with whether insiders associated with acquiring firms seek fewer but more profitable takeovers after the introduction of tighter regulations. These hypotheses have important implications on whether or not insider trading should be prohibited.

In this chapter, Section 2.2 discusses how to make inferences on insider trading using the indirect approach. The issue of information revelation is analyzed and incorporated into the indirect approach. Section 2.3 develops a model in the context of corporate takeovers that establishes the relationships among the regulatory environment, insider trading and the market price response to insider trading. A major proposition obtained from this model is that only when inside information is partially revealed to the market will a change in regulations have effects on price movements prior to takeover announcements. Section 2.4 develops the segmented diffusion model that characterizes the price dynamics during corporate takeovers. Section 2.5 discusses the empirical implications of the models developed in sections 2.3 and 2.4 in terms of testable hypothesis. Finally, section 2.6 concludes the chapter.

2.2 Measuring Insider Trading

We take an indirect approach to the measurement of illegal insider trading based on the potential relationship between regulatory change and the market price response induced by insider trading. In this indirect approach, insider trading can be understood as an intermediate variable that connects the regulatory environment with market prices. If insider trading has a predictable effect on market prices, then a change in insider trading activity due to an effective change of regulations will lead to a change in market price in the anticipated direction. As the change in market price and the change in regulatory environment are observable, we can then make inferences about the effectiveness of the change of insider trading regulations.

The validity of the indirect approach requires one to predict the change of insider trading in response to strengthened regulations, and predict the change of stock prices in response to the change in insider trading. Although it is straightforward to predict the direction of the change of insider trading when regulations become tighter, there is no consensus on how the market incorporates relevant information into stock prices when traders are asymmetrically informed about the value of the stocks. This particular matter is still subject to theoretical debate. There are a number of theories that have been developed to explain pricing behaviour, each of which incorporates different assumptions about the economic environment concerning market structure, traders' behaviour and information structure. Although these theories emerge from different economic environments, the predicted outcomes of the theories generally fall into three categories. The first theory, referred to as full revelation theory, concludes that all the inside information concerning the value of the financial asset is revealed to the market in the equilibrium price, thereby outsiders are able to uncover the inside information simply through observing the market price.[16] The second theory, referred to as partial revelation theory, concludes that inside information is revealed in part to the market in the equilibrium price so that outsiders are unable to uncover fully the inside information but can, to some extent, make reasonable inferences about what insiders might have observed.[17] The third theory, referred to as non-revelation theory, concludes that inside information is not reflected at all in the market equilibrium price, therefore outsiders would never gain any additional information by monitoring the market prices.[18]

Different economic environments, reflected by different kinds of information revelation, will produce different price effects when insider trading activity changes. Therefore, we need to analyze

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[16] Under the assumption of rational expectations, Kihlstrom and Mirman (1975) demonstrate the potential existence of a fully revealing equilibrium in a competitive market with asymmetrically informed agents. Grossman (1976, 1978) provides an example of a fully revealing equilibrium in a competitive market with diverse beliefs, when the joint distribution of prices and the asset returns is normal. For a stochastic economy with general preferences and general distributions of random variables, Allen (1981, 1982), Jordan (1983) and Radner (1979) show that a fully revealing rational expectations equilibrium exists generically as long as the dimension of the state space of private information is less then the dimension of the price space. In this type of market system, equilibrium prices are invertible functions of private information and the functions are known to all agents in the economy so that they are able to interpret the prices for the information not directly observable to them. Green (1977) and Kreps (1977) provide counter examples of non-existence of a fully revealing equilibrium when demand is discontinuous in price functions. Jordan (1982) shows that fully revealing rational expectations equilibria do not exist generically when the dimension of the state space of private information is greater than the dimension of the price space. The fully revealing equilibrium in a competitive market, however, does not provide the rationale what is the incentive for information acquisition if information is costly to obtain.

[17] For a competitive economy, Grossman and Stigliz (1980) provide an example of a partially revealing equilibrium under asymmetric information. Admati (1985), Diamond and Verrecchia (1981), and Verrecchia (1982) provide examples of a partially revealing equilibrium under diverse information. Ausubel (1990) demonstrates that partially revealing equilibria exist for a pure exchange economy with asymmetrically informed agents and general preferences. The partially revealing rational expectations equilibrium in a competitive economy, however, does not reconcile agents' price taking behaviour with the fact that their decision actually affect prices. For a non-competitive economy, assuming that insiders are large traders, Bhattacharya and Spiegel (1991), Fishman and Hagerty (1992), Grinblatt and Ross (1985), Kyle (1985, 1989) and Leland (1992) demonstrate the existence of a rational expectations equilibrium in which private information is not fully revealed. In the context of dynamic trading, Grundy and McNichols (1990), Kyle (1985) show that private information is revealed gradually through trading, and in the end of the trading all the private information is revealed.

[18] Kyle and Vila (1991), and Laffont and Maskin (1990) construct models for the market of imperfect competition in which a large insider with monopoly power is able to manipulate the market price. There are two kinds of equilibria being identified: a pooling equilibrium and a complete separating equilibrium. In the pooling equilibrium, inside information is not at all revealed to the market.

the market price response separately for each particular economic environment. As a strategy for conducting empirical investigation, we distinguish different economic environments from their predicted outcomes rather than from their prescribed assumptions. This is because it is virtually impossible to directly justify various assumptions that specify an economic environment from which a theory emerges. For this reason, we take the equilibrium property as a starting point in the development of a model that measures the price response to the change of insider trading. Furthermore, since insider trading associated with different corporate events may also create different market price reactions, the relationship between insider trading and market price movements could potentially depend on the type of corporate events. As indicated by empirical evidence, illegal insider trading is most frequently associated with corporate takeovers. Therefore we focus on this event.

We next turn to the modelling of the relationship among regulatory change, insider trading and the price movement in the particular context of corporate takeovers under three different scenarios of information revelation.

2.3 Relations Among Regulatory Changes, Insider Trading and Price Movements

Consider a successful corporate takeover event that occurs during a time period $[\, t_0-T_1 \,,\, t_0+T_2 \,]$, $T_1 > 0$ and $T_2 > 0$.[19] At time t_0, the takeover target is identified and the takeover attempt is declared. There are two types of traders, referred to as insiders and outsiders, engaging in the exchange of the target firm's shares during the period $[\, t_0-T_1 \,,\, t_0+T_2 \,]$. Suppose the total supply of the shares is an exogenously determined stochastic process S_t, which is not

[19] The analysis is assumed to be carried out in a continuous time stochastic economy. Let $(\mathscr{E}, \mathscr{F}, P)$ be a complete probability space. $\mathscr{E}$ is an event set which consists all possible states of the world in a closed time interval $[\, t_0-T_1 \,,\, t_0+T_2 \,]$; $\mathscr{F}$ is a σ-field of subsets of $\mathscr{E}$; P is a probability measure on $\mathscr{F}$. Uncertainty is resolved over time according to some filtration $F=\{\mathscr{F}_t \,,\, t \in [\, t_0-T_1 \,,\, t_0+T_2 \,]\,\}$, where $\mathscr{F}_t$ is an increasing family of sub-σ-fields of $\mathscr{F}$ such that $\mathscr{F}_s \subset \mathscr{F}_t$ for $s \le t$, and $\mathscr{F}_{t_0+T_2} = \mathscr{F}$. A stochastic process X_t is observable at t meaning that X_t is $\mathscr{F}_t$ measurable or F-adapted. A stochastic process X_t is not observable at t meaning that X_t is not $\mathscr{F}_t$ measurable but $\mathscr{F}_{t+}$ measurable instead, where $\mathscr{F}_{t+} = \bigcap_{s>t} \mathscr{F}_s$.

instantaneously observable to either type of trader.[20] Suppose further that the demand of each type of trader for the shares is a time-varying function which is exogenously given and known only to that type of trader (to be specified later).

Let the superscript i denote the insiders and o the outsiders. Each type of trader is endowed with an information process Y_t^k (k = i, o). In addition to Y_t^k, each type of trader observes instantaneously a market signal V_t, representing the market value at t of the gain from the takeover to the target. The two types of traders, however, have different beliefs about the intrinsic value of the gain from the takeover to the target. Denote $V_t^i(V_t, Y_t^i)$ the insiders' expectation at t of the intrinsic value of the gain from the takeover to the target conditional on information received by insiders up to t. The insiders' expectation is an exogenously determined function of the market signal V_t and insiders' private information Y_t^i. Similarly, denote $V_t^o(V_t, Y_t^o)$ the outsiders' expectation at t of the intrinsic value of the gain from the takeover to the target conditional on information received by outsiders up to t. The outsiders' expectation is an exogenously determined function of the market signal V_t and outsiders' private information Y_t^o. The functions $V_t^k(\cdot,\cdot)$ (k = i, o) vary over time reflecting that there might be other factors, in addition to the two variables, changing over time that also influence traders' expectations.[21]

Notice that the expectations V_t^k are not only a function of private information Y_t^k, but also a function of the market signal V_t. This implies that both traders would use the market signal in making inferences about the intrinsic value of the gain from the takeover to the target. We assume an asymmetric information structure in which insiders are better informed than outsiders in the sense

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[20] The exogenous supply of the shares of the target firm can be understood as exogenous supply provided by noise traders.

[21] Implicitly, we assume that v is the intrinsic value of gain from the takeover which ic a random variable measurable with respect to $\mathscr{F}$. Let $\mathscr{F}_t^k = \sigma\{V_t, Y_t^k\}$ (k = i, o) be the information sets of k type of traders, which is the σ-fields generated by the market signal V_t, and the private information Y_t^k. V_t and Y_t^k are stochastic processes measurable with respect to $\mathscr{F}_t$. Then $V_t^k(V_t, Y_t^k) = E\{v|\mathscr{F}_t^k\}$. This assumption is motivated by classic finance theory that a security price is the present value of the expected future payoffs to the security, irrespective of the demand and the supply of the security.

that $V_t^i(V_t\ ,\ Y_t^i) \geq V_t^o(V_t\ ,\ Y_t^o)$.[22] Assume further that the market signal conveys no additional information to insiders, i.e., $\frac{\partial V_t^i}{\partial V_t} = 0$. However, the market signal may convey information to outsiders, depending on whether inside information is revealed to the market. Specifically, if inside information is revealed to the market, then $\frac{\partial V_t^o}{\partial V_t} > 0$; if not, then $\frac{\partial V_t^o}{\partial V_t} = 0$. We also assume that information asymmetry exists only before the takeover announcement. Specifically, if information is fully revealed, then $V_t^i(V_t\ ,\ Y_t^i) = V_t^o(V_t\ ,\ Y_t^o)$; if information is partially revealed or not revealed at all, then $V_t^i(V_t\ ,\ Y_t^i) > V_t^o(V_t\ ,\ Y_t^o)$. After the takeover announcement, information asymmetry disappears and the market signal does not convey any additional information, therefore for both types of traders, $\frac{\partial V_t^k}{\partial V_t} = 0$ (k = i, o) and $V_t^i(V_t\ ,\ Y_t^i) = V_t^o(V_t\ ,\ Y_t^o)$. Assumption (A1) summarizes the above reasoning.

<u>Assumption (A1):</u>

Before the takeover announcement (i.e., $t < t_0$), $\frac{\partial V_t^i}{\partial V_t} = 0$, and

i) Under full revelation, $\frac{\partial V_t^o}{\partial V_t} > 0$ and $V_t^i = V_t^o$;

ii) Under partial revelation, $\frac{\partial V_t^o}{\partial V_t} > 0$ and $V_t^i > V_t^o$; and

iii) Under non-revelation, $\frac{\partial V_t^o}{\partial V_t} = 0$ and $V_t^i > V_t^o$.

After the takeover announcement (i.e., $t \geq t_0$), $\frac{\partial V_t^k}{\partial V_t} = 0$ (k = i, o) and $V_t^i = V_t^o$.

The demand of each type of trader for the shares of the target firm is an exogenously determined function that depends on the expectation of that type of trader about the intrinsic value of the gain from the takeover V_t^k, and a regulatory environment variable l. Assume that l is an exogenously given deterministic variable ($l > 0$). A higher value of l indicates more strict

[22] This is motivated by the fact that corporate takeovers on average create positive abnormal returns to the target firm. For empirical evidence on this, see, for example, Bradley, Desai and Kim (1988), Keown and Pinkerton (1981), and Stulz, Walkling and Song (1990).

Throughout our analysis, if X and Y are random variables, then the expression of $X = Y$, $X > Y$ and $X < Y$ means $X = Y$ a.s., $X > Y$ a.s. and $X < Y$ a.s., respectively. A similar specification holds when Y is a constant.

regulations of insider trading. For the time being, we consider only the case when the regulatory change is effective. Assume that the demand of each type of trader at t can be written as $D_t^k(V_t^k, l)$ (k = i, o), and $\frac{\partial D_t^k}{\partial V_t^k} > 0$ for both insiders and outsiders. As insiders' trades are subject to the regulations and a more strict regulatory environment would permit fewer insiders' trades, it follows that $\frac{\partial D_t^i}{\partial l} < 0$. However, the regulations do not apply to outsiders' trades and therefore have no direct impact on outsiders' demand, it follows that $\frac{\partial D_t^o}{\partial l} = 0$.

We also assert an assumption regarding equilibrium price formation under partial revelation. In particular, we assume that the market value of the gain from the takeover is a weighted average of the two types of traders' expectations, with the weights being the ratio of each type of traders' demand over the total demand.

Assumption (A2):

Under partial revelation, the market value of the gain from the takeover is characterized by

$$V_t = \frac{D_t^i}{D_t^i + D_t^0} V_t^i + \frac{D_t^o}{D_t^i + D_t^o} V_t^o \ . \tag{1}$$

Notice that since the total demand at t, which is equal to the total supply S_t, is not instantaneously observable to any type of trader, thus outsiders are unable to interpret precisely the information that insiders possess.

Under assumptions (A1) and (A2), we show that the change in V_t due to the change in regulations reflects the change in insider trading, so the change in V_t can be used as an indirect measure of illegal insider trading.

Proposition 1:

If the regulatory change is effective, then before the announcement, i.e., $t < t_0$,

i) under full revelation or non-revelation, $\frac{dV_t}{dl} = 0$;

ii) under partial revelation, if $\frac{dV_t^o}{dV_t} \leq 1$, then $\frac{dV_t}{dl} < 0$.

After the announcement, i.e., $t \geq t_0$, $\frac{dV_t}{dl} = 0$.

Proof.[23] Consider first when $t < t_0$. Under full revelation, the signal V_t conveys all inside information so that conditional on V_t outsiders become as informed as insiders, that is, $V_t^o = V_t^i$ (A1(i)). Given this and the assumption of rational expectations, it must be that the market value at t of the gain from the takeover is the same as the insiders' expectation of the intrinsic value of the gain from the takeover, i.e., $V_t = V_t^i$. Under non-revelation, on the other hand, inside information is not revealed at all to the market, therefore it must be that the market value at t of the gain from the takeover is the same as outsiders' expectation of the intrinsic value of the gain from the takeover, i.e., $V_t = V_t^o$. This is because that if not, outsiders would be able to make inferences about inside information from the difference between the market signal V_t and their own expectation V_t^o. Since under either full revelation or non-revelation, the regulatory variable l does not enter the equilibrium condition, it follows that $\frac{dV_t}{dl} = 0$. Under partial revelation, from (A2) we have

$$\frac{dV_t}{dl} = \frac{1}{(D_t^i + D_t^o)^2}\left[(\frac{\partial D_t^i}{\partial l}D_t^o - D_t^i\frac{\partial D_t^o}{\partial V_t}\frac{dV_t}{dl})V_t^i + (\frac{\partial D_t^o}{\partial V_t}\frac{dV_t}{dl}D_t^i - D_t^o\frac{\partial D_t^i}{\partial l})V_t^o\right] + (\frac{D_t^o}{D_t^i + D_t^o})\frac{\partial V_t^o}{\partial V_t}\frac{dV_t}{dl}. \qquad (2)$$

Solving equation (2) for $\frac{dV_t}{dl}$ yields,

$$\frac{dV_t}{dl} = \frac{D_t^o(V_t^i - V_t^o)\frac{\partial D_t^i}{\partial l}}{D_t^i(V_t^i - V_t^o)\frac{\partial D_t^o}{\partial V_t} + (D_t^i + D_t^o)^2 - D_t^o(D_t^i + D_t^o)\frac{\partial V_t^o}{\partial V_t}}. \qquad (3)$$

Since $\frac{\partial D_t^i}{\partial l} < 0$ and, by (A1), $V_t^i - V_t^o > 0$, then $D_t^o(V_t^i - V_t^o)\frac{\partial D_t^i}{\partial L} < 0$. Since $\frac{\partial D_t^o}{\partial V_t} > 0$, then $D_t^i(V_t^i - V_t^o)\frac{\partial D_t^o}{\partial V_t} > 0$. Finally, $\frac{\partial V_t^o}{\partial V_t} \leq 1$ implies that $(D_t^i + D_t^o)^2 - D_t^o(D_t^i + D_t^o)\frac{\partial V_t^o}{\partial V_t} > 0$. Therefore, $\frac{dV_t}{dl} < 0$.

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[23] Let $\omega \in \mathscr{E}$ and $t \in [t_0 - T_1, t_0 + T_2]$. Fixing (ω, t), then $V_t = \theta_t V_t^i + (1 - \theta_t)V_t^o$ is a deterministic equation of L. Therefore the deterministic calculus applies. The binary relationships appeared in the proof, however, are understood in the same way as being specified by footnote 22.

When $t \geq t_0$, information asymmetry disappears. Therefore, under rational expectation it must be that $V_t = V_t^i = V_t^o$. Since l does not enter the equilibrium condition, $\frac{dV_t}{dl} = 0$. This completes the proof.

The condition $\frac{\partial V_t^o}{\partial V_t} < 1$ under partial revelation can be understood as a stability condition imposed on the nature of the learning process of outsiders. It requires outsiders not to over-adjust their expectations upon observing the market signal V_t. Because in the equilibrium, outsiders' interpretation about the market signal V_t is instantaneously impounded back to V_t via V_t^o, over-adjustments of V_t^o would lead to possibly the explosion of V_t. Consequently the equilibrium would not be sustained.

The stochastic process V_t represents the market value of the gain from the takeover to the target firm which can be understood as the incremental value of the target firm over the firm's value without a takeover. If the firm's value without a takeover is taken as a benchmark, then V_t can be captured by the cumulative abnormal returns to the target firm over the benchmark returns. The correspondence between V_t and the cumulative abnormal returns to the target allows us to examine the stochastic process V_t through examining the cumulative abnormal returns. We now discuss the dynamic specification of the abnormal return process during the event period of a corporate takeover.

2.4 Price Movements During Corporate Takeovers

Empirical research on stock price behaviour indicates that short run (less than 6 months) daily returns seem to be serially uncorrelated, although the long run (more than three years) daily returns could be serially correlated.[24] The evidence seems to be consistent for both individual stocks and a portfolio. If cumulative abnormal returns are measured as the sum of the abnormal returns over some portfolio, then modelling the cumulative abnormal returns as an Ito process is consistent with empirical observations of stock daily returns.

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[24] Fama (1970, 1991) provides an excellent survey on this issue.

The added value of the takeover to the stock price is captured by the drift term of the Ito process. Because the rates at which the value of the gain from the takeover is capitalized could differ before and after the announcement, the cumulative abnormal returns may follow different drifts before and after the announcement. Therefore a segmented Ito process with a switch in its mean drift at the announcement time is introduced to capture the switch in the rate of capitalization process around the announcement.

Since our focus is on the price behaviour around the announcement time, we use a stochastic model in which the return process is most accurate at the announcement time, but whose instantaneous variance increases as t diverges from the announcement time. This particular concern motivates us to consider a time-reflecting Brownian motion (to be defined below). In this section, we first construct a time-reflecting Brownian motion, then we present the dynamic specification of the cumulative abnormal returns as a segmented Ito process built on the time-reflecting Brownian motion.

2.4.1 Time-reflecting Brownian motion

Let W_t^1 be a standard Brownian motion starting at t_0-T_1, and W_t^2 be a standard Brownian motion starting at t_0. W_t^1 and W_t^2 are independent. Then a time-reflecting Brownian motion is a stochastic process W_t such that:

$$W_t = \begin{cases} W_{t_0}^1 - W_t^1 , & t_0-T_1 \le t < t_0 \\ W_t^2 , & t_0 \le t \le t_0+T_2 \end{cases} \tag{4}$$

In this time-reflecting Brownian motion, the motion in the time interval $[t_0-T_1 , t_0]$ is exactly the mirror image of the motion in the time interval $[t_0 , t_0+T_2]$. The following lemma demonstrates that the instantaneous variance of W_t is 0 at time $t = t_0$ and increases as t diverges from t_0.

<u>Lemma 1:</u>

W_t is a Brownian motion with zero instantaneous variance at $t = t_0$.

Proof. By definition, W_t^1 is a standard Brownian motion with $W_{t_0-T_1}^1 = 0$ a.s. By the property of time-reversal Brownian motion (Karatzas and Shreve (1991), p 104), $W_{t_0}^1 - W_t^1$ is also a standard Brownian motion with $W_{t_0}^1 - W_{t_0}^1 = 0$ a.s. Finally, also by definition, W_t^2 is a standard Brownian motion with $W_{t_0}^2 = 0$ a.s. Therefore, W_t is a Brownian motion with $W_{t_0} = 0$ a.s. This completes the proof.

2.4.2 Capitalization process of the takeover event

Empirical evidence indicates that price movements around the takeover announcement date are quite different before and after the announcement.[25] Before the announcement date, the target firm's stock price exhibits a gradual increase, measured in terms of price run-ups in the target firm's cumulative abnormal returns. The run-up becomes notable around 15-20 days before the announcement, increases gradually in an increasing rate, and becomes quite substantial as it is approaching the announcement date. Within one or two days following the announcement, the price of the target firm surges up by a significant amount and the cumulative abnormal returns exhibit a sudden jump. Afterwards the price of the target firm stabilizes and the abnormal return to the target firm disappears.

We adopt a segmented diffusion process to capture this pattern of the cumulative abnormal returns associated with takeover targets. The diffusion process is characterized by two Brownian motions with different linear drift switching at the announcement time.[26] Let $t \in [\, t_0-T_1 \,, \, t_0+T_2 \,]$ and CAR_t be the cumulative abnormal return to the target at t. Conceptually, abnormal returns to the target firm are the excess returns to the target if the event occurs over the returns to the target if the event does not occur. Denoting AR_t the abnormal returns at t, then the cumulative abnormal

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[25] See, for example, Keown and Pinkerton (1981), Givoly and Palmon (1985) and Jarrell and Poulsen (1989).

[26] Whether this specification is an ideal approximation remains, of course, an empirical question. Some justifications of the specification are provided later in this study when empirical results are presented.

returns CAR_t can be written as $\int_{t_0-T_1}^{t} AR_\tau d\tau$.[27] Let $\hat{CAR}^*$ the expected total cumulative abnormal return over the event period $[t_0-T_1 , t_0+T_2]$. The diffusion process is then represented by the following differential equation:

$$dCAR_t = \begin{cases} \alpha CAR_t dt + \sigma dW_t , & t < t_0 \\ \beta(\hat{CAR}^* - CAR_t) dt + \sigma dW_t , & t \geq t_0 \end{cases} \tag{5}$$

where t_0 is the announcement time. Before the announcement time, the cumulative abnormal returns are on average increasing at an increasing rate, αCAR_t, with $\alpha > 0$. After the announcement, the returns are on average increasing at a decreasing rate, $\beta(\hat{CAR}^* - CAR_t)$, with $\beta > 0$. For simplicity, we assume that the diffusion term, σ, stays constant before and after the announcement.[28] The interpretation of α and β is discussed right after proposition 2.

The model specification here reflects a concern that is to capture the non-linear structure by a simple model specification which is convenient to estimate and flexible enough to cover a large class of price reaction. This particular model specification does not rule out other alterative specifications. Nevertheless, the estimation of more complicated model specification may be difficult.[29]

<u>Proposition 2</u>:

Let $\hat{CAR}_t$ be the expected cumulative abnormal return up to time t. Then the solution to the stochastic differential equation (5) is:

[27] This specification, of course, does not prevent in practice to approximate the conceptual CAR_t with some practical measure of CAR_t using , for example, a market model or a mean adjusted model.

[28] This specification implies that the volatility is the same over time. Although empirical evidence suggests that volatility may change over time, those are mainly long-run effects. Some other studies suggest that volatility may increase during the event period. In our context, this would mean that σ within $[t_0-T_1 , t_0+T_2]$ is greater than σ beyond $[t_0-T_1 , t_0+T_2]$.

[29] Boardman, Vertinsky and Whistler (1992) explored several alternative non-linear model specifications in a study of the effects of regulatory changes on stock prices. They found that their results are not sensitive to the alternative model specification and the simple functional form usually give better results.

$$CAR_t = \begin{cases} \mu^- \hat{CAR}^* e^{\alpha(t-t_0)} + \sigma \int_{t_0}^{t} e^{\alpha(t-s)} dW_s \,, & t < t_0 \\ \hat{CAR}^* - (1-\mu)\hat{CAR}^* e^{-\beta(t-t_0)} + \sigma \int_{t_0}^{t} e^{-\beta(t-s)} dW_s \,, & t \geq t_0 \end{cases} \tag{6}$$

where $\mu^- = \lim_{t \uparrow t_0} \frac{\hat{CAR}_t}{\hat{CAR}^*}$ reflects the price run-up prior to but not including the announcement at time t_0, and $\mu = \frac{\hat{CAR}_{t_0}}{\hat{CAR}^*}$ reflects the price run-up prior to and including the announcement at time t_0.

Proof. The solution to the stochastic differential equation (5) is:

$$CAR_t = \begin{cases} \hat{CAR}_{t_0-\delta} e^{\alpha(t-t_0-\delta)} + \sigma \int_{t_0-\delta}^{t} e^{\alpha(t-s-\delta)} dW_s \,, & t < t_0 \\ \hat{CAR}^* - (\hat{CAR}^* - \hat{CAR}_{t_0}) e^{-\beta(t-t_0)} + \sigma \int_{t_0}^{t} e^{-\beta(t-s)} dW_s \,, & t \geq t_0 \end{cases} \tag{7}$$

with $\delta > 0$. Now using the definition of μ^- and μ and let $\delta \to 0$, equation (7) converges to equation (6). This completes the proof.

The parameter μ^- can be interpreted as price run-up prior to but not including the announcement, and the parameter μ can be interpreted as price run-up prior to and including the announcement. When $\mu^- \neq \mu$, CAR_t is a right continuous diffusion process with a jump that occurs at $t = t_0$. The jump reflects that new information (the takeover announcement) arrives at $t = t_0$.

The parameter α captures the rate of price run-up before the announcement, reflecting how fast the market reacts to unanticipated price adjustments. β is the rate of price run-up after the announcement which is influenced by the uncertainty associated with the success of the event. Greater uncertainty about the outcome of the event implies a smaller β. With uncertainty, even when the market is efficient, parameter μ will always be less than 1.

As CAR_t can be measured, we can use estimated changes in μ^- and μ to test hypotheses associated with μ^- and μ. This is the subject of the following section.

2.5 The Impact of Regulatory Change on Price Movements

Recall from section 2.3 that V_t is the market value of the gain from takeover of the target at time t. Also recall from the preceding section that the segmented diffusion process captures cumulative abnormal returns to the target during the takeover. As we mentioned earlier, if the cumulative abnormal returns were excess returns over the returns to the target without the takeover, then V_t would be captured by CAR_t. Therefore the correspondence between V_t and CAR_t provides us with a basis for making inferences about the effects of regulatory changes by analyzing the segmented diffusion process.

In this section, we characterize regulatory effects on insider trading by changes in parameters of the segmented diffusion model. The characterization translates the effects of regulatory changes into testable hypothesis. Specifically, we analyze the impact of regulatory changes on insider trading independently for two types of takeovers: negotiated takeovers and takeovers initiated by bidding. Negotiated takeovers are referred to as takeovers resulting from negotiation between the acquiring firm and the target firm. Takeovers initiated by bidding are referred to as takeovers that begin with an open proposal of acquisition prepared by the acquiring firm.[30] We distinguish between these two types of takeovers because we suspect that the regulatory change is likely to impact them differently.

2.5.1 Information revelation and the effectiveness of regulatory change

Recall from section 2.2 that the variable l measures the strictness of regulations. Prior to the announcement, $\frac{dV_t}{dl}$ is the indirect measure of the change of illegal insider trading due to the change of regulatory regimes (proposition 1). Also recall that μ^- and μ measure the price run-up prior to the announcement and the price run-up prior to and including the announcement. Since price run-ups are defined in terms of the expected cumulative abnormal returns relative to the expected total cumulative abnormal return over the entire event period, then $\frac{d\mu^-}{dl}$ reflects $\frac{dV_t}{dl}$ when t is the moment immediately before the announcement, and $\frac{d\mu}{dl}$ reflects $\frac{dV_t}{dl}$ when t is the moment of the

[30] More detailed specifications of the types of takeovers are to be presented when the empirical study is carried out.

announcement. Therefore, it follows from Proposition 1 that $\frac{d\mu^-}{dl}$ is also an indirect measure of the change in insider trading in response to the change of the regulatory environment, and $\frac{d\mu}{dl}$ is always 0 irrespective of the change of the regulatory environment.

Table I synthesises all scenarios for the changes in price run-ups under different type of information revelation and different degrees of regulatory change. If the regulatory change is not effective, there will be no change in the price run-up prior to the announcement time. If, on the other hand, the regulatory change is effective, and if information is partially revealed to the market, then $\frac{d\mu^-}{dl} < 0$; if information is not revealed or fully revealed to the market, then $\frac{d\mu^-}{dl} = 0$. At the same time, in all possible scenarios $\frac{d\mu}{dl} = 0$. From table I, we obtain the following hypothesis:

Hypothesis I: The tightening of regulations in the 1980's is effective and inside information is partially revealed to the market, that is, $\frac{d\mu^-}{dl} < 0$ and $\frac{d\mu}{dl} = 0$.

Table I

The Effects of Regulatory Change on Price Run-Ups

	Full Revelation	Partial Revelation	None Revelation
Effective Change	$\frac{d\mu^-}{dl} = 0, \frac{d\mu}{dl} = 0$	$\frac{d\mu^-}{dl} < 0, \frac{d\mu}{dl} = 0$	$\frac{d\mu^-}{dl} = 0, \frac{d\mu}{dl} = 0$
Ineffective Change	$\frac{d\mu^-}{dl} = 0, \frac{d\mu}{dl} = 0$	$\frac{d\mu^-}{dl} = 0, \frac{d\mu}{dl} = 0$	$\frac{d\mu^-}{dl} = 0, \frac{d\mu}{dl} = 0$

Hypothesis I does not permit us to distinguish between all states in table I. However, we can determine whether the market is partially revealing or not partially revealing, and whether the change in regulatory regime is effective or not.

2.5.2 Negotiated takeovers versus takeovers initiated by bidding

In this thesis, we suggest for the first time that the intensity of insider trading in negotiated takeovers is different from that in takeovers initiated by bidding. There are several reasons for this. First, negotiated takeovers are more vulnerable to information leakage. Negotiated takeovers involve more people, include two management teams, their financial and legal advisors, and their supporting staffs, whereas takeovers initiated by bidding involve a relatively smaller group of personal, only the bidding firm management, its financial and legal advisor, and its own supporting staff. Also, the course of negotiation is usually lengthy, and negotiations are relatively less secretive than the preparation of a bid. Secondly, the takeover process for negotiated takeovers is more vulnerable to regulations. In the case of takeovers initiated by bidding, insiders involved in takeover decision-making have more flexibility to substitute illegal insider trading with legal insider trading through the coordination of the timing of their trades and the timing of the takeover process. Therefore the impact of the regulatory change could be greater on the negotiated takeovers than on the takeovers initiated by bidding. We use superscript N and B to distinguish between negotiated takeovers and takeovers initiated by bidding. Then we hypothesize the following property:

Hypothesis II: The impact of regulatory change is greater on the negotiated takeover than on the takeovers initiated by bidding, that is, $|\frac{d\mu^{-N}}{dl}| > |\frac{d\mu^{-B}}{dl}|$.

2.5.3 The cost of regulation

As discussed in chapter 1, insider trading is most frequently associated with takeovers. Kyle and Vila (1991) demonstrate that insiders who seek takeovers will view insider trading profit as part of their compensation for the costs of taking over a target. In their model, unless insiders obtain a large enough profit from pre-takeover trading to cover the costs of engaging in the takeover, the takeover will not occur. If insider trading is indeed motivated by the reason advanced by Kyle-Vila, insider trading profit must increase for successful takeovers as the costs of takeover increase. If one views the penalties imposed on insider trading by the insider trading regulations as part of the costs to insiders who seek takeovers, then tightening of insider trading regulations increases the costs of takeovers to the insiders.

In a discussion of the effects of increased disclosure requirements on tender offers, Jensen and Ruback (1983) suggest that increased regulation imposes higher costs on the bidder, in effect, truncating the distribution of the takeovers that would actually occur. The essence of the " truncation effect" is that the tightened regulation increases the costs of takeovers. As we discussed above, increased insider trading regulation also increase the costs of takeovers, therefore we would observe the same truncation effect hypothesized by Jensen-Ruback. That is, when regulations become more strict, insiders as acquirers would seek, on average, more profitable takeovers. The truncation effect predicts higher total cumulative abnormal returns after regulations become tighter. Thus, $\Delta\hat{CAR}^{*} > 0$.

Furthermore, under Hypothesis II insider trading in negotiated takeovers is more responsive to the regulatory change. Thus, the increase in the expected total cumulative abnormal return of negotiated takeovers, $\Delta\hat{CAR}^{*N}$, will be greater than the increase of the expected total cumulative abnormal return of takeovers initiated by bidding, $\Delta\hat{CAR}^{*B}$.

Combining the above we then have the following hypothesis:

Hypothesis III: When regulations of insider trading are tightened, the increase of the expected total cumulative abnormal return of negotiated takeovers is greater than the increase of the expected total cumulative abnormal return of takeovers initiated by bidding, that is, $\Delta\hat{CAR}^{*N} > \Delta\hat{CAR}^{*B} \geq 0$.

2.6 Conclusion

This chapter develops a model, in the context of corporate takeover, that establishes the relationship among regulatory changes, insider trading and price movements. In this model, information revelation is a key element. The model demonstrate that, when information is only partially revealed to the market, changes in insider trading due to tightened regulation will be reflected in the change of price movements during takeovers. When information is either fully or not at all revealed to the market, change in insider trading will not lead to the change in price movements during takeovers.

The price movements during takeovers are modelled by a segmented diffusion process which captures the cumulative abnormal returns around the announcement time. The segmented diffusion process is determined by five model parameters. By examining changes in the parameters of the model, we can test hypotheses concerning changes of price movements during takeovers. Specifically, the segmented diffusion model allows us to analyze the impact of regulatory change on insider trading and price movements by examining the change of model parameters before and after regulatory changes.

Three hypotheses are introduced. Hypothesis I deals jointly with information revelation and the effectiveness of regulatory changes. Hypothesis II concerns whether the regulatory changes had more impact on insider trading during negotiated takeovers than on insider trading during takeovers initiated by bidding. Hypothesis III deals with whether insiders associated with acquiring firms or groups seek fewer but more profitable takeovers after the introduction of tighter regulations. Evidence on these hypothesis will allow us to make inferences whether insider trading improve stock price efficiency or whether insider trading regulations reduce the incentive for undertaking takeovers. These hypotheses will be tested empirically in Chapter 4.

We now turn to estimation of the segmented diffusion model.

2.7 References

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Chapter Three

ESTIMATING TIME VARYING CAPITALIZATION PROCESSES

3.1 Introduction

This chapter deals with the estimation of the segmented diffusion model developed in Chapter 2. The segmented diffusion model studies the pattern of cumulative abnormal returns (CARs) over the period of interest. Using the pattern of CARs to analyze the price effect of an event appeared first in Fama, Fisher, Jensen and Roll (1969). While this traditional method provides useful information about the price movements during an event period, until recently there was no statistical model incorporated into the analysis of CARs. Boardman, Vertinsky and Whistler (1992) introduce non-linear regression analysis into this approach thereby making it possible to carry out statistical analysis of the pattern of CARs. They model various patterns of CARs by differential equations and measure the effect of an event with parameters determining the differential equations. The Boardman-Vertinsky-Whistler (BVW) method, however, is limited to certain types of price reactions to the event. It may encounter estimation problems when price adjustments to the event is concentrated in one or two days. In general, the estimation problem associated with the BVW method are of two kinds: an underestimation problem and an identification problem. The segmented diffusion model is designed to overcome both problems encountered in BVW.

The segmented diffusion model differs from the BVW method in several aspects. First, to deal with the estimation problems encountered in BVW, we introduce an approximation that is able to reduce the difficulty of estimating a non-linear structure. Our approach is to estimate a system of simultaneous equations including a discrete approximation of a stochastic differential equation and the solution to the differential equation. This system in effect approximates the original non-linear model by asserting a piece-wise linear structure between every (daily) observations. Second, the segmented diffusion model allows for a possible drastic change in the pattern of the CARs around the event announcement itself, thereby extending the BVW method to deal with non-symmetric patterns in the CARs, even when overshooting of price adjustments occurs around the announcement. Third, our method incorporates all information about the pattern of the CARs, because we incorporate both the differential equation and its solution in the estimation. In contrast, the BVW method considers only one of them and it dose not provide full information about the pattern of the CARs when estimation uses only the differential equations.

The segmented diffusion model applies to events besides corporate takeovers. In this chapter, we demonstrate that, with only a few parameters, the model can capture a number of different price reactions to various events. They include events of either positive or negative economic values, anticipated or unanticipated events, and events with gradual or sharp price reactions, possibly exhibiting some overshooting phenomenon. In contrast with other methods of event studies, one advantage of the segmented diffusion model is its convenience in dealing with time-varying capitalization processes.

The estimation of the system of equations is through non-linear full information maximum likelihood (NLFIML) method. To apply NLFIML, we first show that the error terms of the model have a multivariate normal distribution. This follows from the assumptions about the dynamic specification of the capitalization process during the event period. We then show that the true covariance matrix of the error terms possesses the properties required by NLFIML estimation. There are two advantages of using NLFIML to estimate the segmented diffusion process. First, the NLFIML estimates have nice properties. Second, as we show in this chapter, the estimation of the model is easy to apply computationally because the objective function for the maximum likelihood estimation can be simplified into the sum of squared terms.

One important application of the segmented diffusion model is to analyze the effects of regulatory changes on stock prices. Using stock prices to study regulatory impacts can be traced back to Stigler and Friedland (1962). Such an method is further promoted by Schwert (1981). More sophisticated methods of study regulatory effects appear later in Schipper and Thompson (1983) and Binder (1985). Our methodology of study regulatory effects derived from the segmented diffusion model differs from other methodologies including those mentioned above. Our method incorporates two kinds of events: a "regulatory event" that takes place *gradually* over a long time period (e.g., the strengthening of insider trading regulations), and a "corporate event" that takes place within a few days (e.g., the event of corporate takeovers). The nature of our analysis requires us to make statistical inferences about the effects of *both* kinds of events simultaneously. The existing methodologies of studying regulatory effects, however, do not immediately applicable to problems of this kind. To deal with this kind of problems, we capture the *gradually* changing regulatory environment by identifying two regulatory regimes that are widely separated over time, and construct a system equations that combines two segmented diffusion models, each of which captures price reactions to the takeover event in one of the regulatory regimes. By analyzing this system, we can estimate both effects of the regulatory event and the corporate event and test they directly. A discussion of this method is included in section 3.4.

We start in section 3.2 with an overview of event study methodologies. The review highlights the advantages and disadvantages of traditional event study methodologies and motivates the adoption of the segmented diffusion model in our event study. Section 3.3 provides the econometric foundation for the segmented diffusion model so that statistical inferences can be made. Section 3.4 discusses the implication of the segmented diffusion model including applications in various kinds of event studies. Finally, section 3.5 offers concluding remarks.

3.2 An Overview of Event Study Methodologies

The purpose of event studies is to assess the impact of particular events on the stock prices of affected firms. This task is accomplished through the analysis of abnormal returns or CARs to the firms' stock over a period surrounding the event. The abnormal return is usually measured in terms of excess return on the firm's stock over a specific benchmark return which is considered as being normal. In practice, a wide variety of alternative choices for the benchmark return have been used to determine the abnormal return. Although there seem to be lack of consensus in the choice of the benchmark return, the Sharpe (1964) and Lintner (1965) Capital Asset Pricing Model (CAPM) and its variants have appeared to be the most frequently used theory by which the benchmark return is determined.[31]

From the view point of how the abnormal returns are estimated, the various approaches in event studies seem to fall into three categories. The first type of approach, sometimes referred to as residuals analysis, constructs an average abnormal return statistic or a cumulative average abnormal return statistic and then verifies whether they are significantly different from zero. In this approach, the time series data are divided into an event period and a non-event period. The time period during which the event is presumed to take place is called the event period, and the rest is

[31] Other methods to compute abnormal returns based on alternative choices for the benchmark return include mean-adjusted return proposed by Masulis (1980), market-adjusted return used early by Latane and Jones (1979). Brown and Warner (1980) provide a comprehensive survey on use of various benchmark returns. In many recent event studies, the combination of the two factor model of Sharpe-Lintner version of CAPM with other firm characteristics such as size, price/earnings ratio, etc. has been used to modify the CAPM. We refer to these modified CAPMs as the variants of the CAPM. Other methods used to determine the benchmark return include the factor model based on the arbitrage pricing theory of Ross (1976). For models based on mainly the macroeconomic factors, see, for example, Chamberlain and Rothschild (1983), Chen, Roll and Ross (1986) and Conner and Korajczyk (1986, 1988). For models based on mainly the firm specific factors, see, for example, Fama and French (1992, 1993).

called the non-event period. The parameters that determine the benchmark returns are estimated based on the information provided by the non-event period. Once the benchmark is determined, the abnormal returns during the event period are calculated in terms of residual differences between the actual returns and the benchmark returns. These residuals are usually not conditional on whether or not the event is occur and thus are referred to as *unconditional residuals*. The average abnormal return statistic is an arithmetic average of abnormal returns (time series and/or cross sectional) and the cumulative average abnormal return statistic is usually the sum of average abnormal returns over time. Under certain assumptions about the return generating process, it can be shown that these statistics have a t-distribution or a normal distribution. Thus statistical inferences can be carried out.

The early version of this method appears in Fama (1965), Ball and Brown (1968) and Fama, Fisher, Jensen and Roll (1969). May (1971) introduces z-statistic into the residuals analysis for large samples. Jaffe (1974), Mandelker (1974) and Patell (1976) introduce t-statistics into residuals analysis. In order for the abnormal return statistic to have a t-distribution, unconditional residuals of security returns must be normally distributed. This is a rather strong assumption which is sometimes not met. For example, Fama (1976) and Brown and Warner (1985) notice that the distribution of unconditional residuals of security returns could be non-normal, especially for daily stock returns. If so, the average abnormal return statistic will not follow a t-distribution.[32]

The second approach, sometimes referred to as the event parameter approach, estimates the abnormal returns directly through a time-series/cross-sectional multiple regression analysis.[33] One

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[32] In response to this, Corrado (1989) proposes to use a non-parametric approach to test the significance of the average abnormal return statistic. Subsequently, Campbell and Wasley (1993) find that the non-parametric approach obtains superior estimation for some daily returns.

[33] The original version of this approach appears in Schipper and Thompson (1983) and Thompson (1985). Malatesta and Thompson (1985) extend the method to study partially anticipated events. Malatesta (1986) extends the method to study a number of events that are potentially correlated. Sefcik and Thompson (1986) extend the method to include firm characteristics as explanatory variables. Eckbo, Maksimovic and Williams

common version of the approach is derived from a CAPM based conditional return generating process (CRGP). The CRGP model assumes there is one event period consisting of N sub-periods. Within each sub-period, the price reactions to the event are constant.[34] This process can be represented by a time-series cross-sectional model:

$$R_j = \alpha_j I + \beta_j R_m + \delta_j \gamma_j + \varepsilon_j \quad , \quad j = 1,\ldots,J \tag{8}$$

where

R_j is a $T\times 1$ time series vector of excess return over the riskless rate to security j.

I is a $T\times 1$ vector whose elements are all equal to 1.

R_m is a $T\times 1$ time series vector of excess return over the riskless rate to the market.

δ_j is a $T\times N$ matrix of announcement variables with each column corresponding to one sub-period of the event. The elements of each column vector equal to 1 for the days during which the event is presumed to be taking place with a presumed price effect and 0 elsewhere.

γ_j is a $N\times 1$ vector of event parameters that measures the economic value per event period for each of the N sub-periods.

α_j is an parameter reflecting the expectation of abnormal return, conditional on no announcement being made.

β_j is security j's beta coefficient of the CAPM.

ε_j is a $T\times 1$ vector of mean zero residuals *conditional* on whether or not the event occurs which are uncorrelated with δ_j and R_m.

(1990) extend the method to study events involving asymmetrically informed agents. Malatesta and Thompson (1993) extend the method to study events that are similar in some aspects but different in some other aspects.

[34] Alternatively, the assumptions can be re-specified as there are N event periods taking place sequentially over time. Within each event period, price reactions to the event are constant.

In this model, the event parameter vector γ_j offers a direct measure of the economic value of the event. Under the usual regularity conditions, the one-step multiple regression estimates from the CRGP are BLUE and are more efficient than the estimates obtained from residuals analysis. The assumptions on the CRGP require only that the conditional residuals, not the unconditional residuals, are distributed normal, which is a weaker requirement than the one needed by residual analysis. To the above extent, the CRGP enjoys some advantages over residuals analysis, although it shares many other properties of estimation with residuals analysis. To apply the method, it is necessary to pre-specify the dynamic structure of the abnormal returns with reasonable accuracy. In practice, this requirement is sometimes difficult to satisfy. For example, when the data do not seem to offer clearly a beginning or an ending point for each sub-period of the event, or when the abnormal returns of the event persist for a long period and vary from day to day, then a correct model specification using the CRGP requires complicated segmentation of the time series which could be difficult to determine ex ante.[35] Sometimes, for the sake of practical convenience, it is simply assumed that the price adjustment process during each event period is constant. Such practice could lead to serious model mis-specification.

The third approach, referred to in this thesis as analysis of capitalization processes, studies the pattern of price movements during an event to examine how the economic value of the event is

[35] The difficulty of estimating the CRGP arises when price adjustment is carried over at a changing rate over a period of many days during a specific event. Under this circumstances, a correct model specification using CRGP requires to introduce a large-dimensional vector γ_j into the model to capture the time-varying price adjustment process. Thus an accurate model specification could require many parameters to estimate for a linear model like (8). Furthermore, in order to apply the model, it is necessary to determine a priori the dynamic structure of the price adjustment process. This includes where the event starts and where it ends, and how to partition the event period to determine the dimension of the vector γ_j. There are, however, no theoretical guidelines about how to select one dynamic specification from a number of other potentially possible specifications. In practice, a typical approach to the choice of the dynamic specification when using this model is search by trial and error, which is a complicated procedure when there are many sub-periods need to be determined.

capitalized over time during the event period. In many circumstances, the incremental value of the event is well captured by the cumulative abnormal returns during the event period. This approach is first introduced by Fama, Fisher, Jensen and Roll (1969) and has been remained for a long time as a purely descriptive analysis. Recently, Mittoo (1988), and Boardman, Vertinsky and Whistler (1992) (BVW) introduce non-linear regression analysis into this approach, which makes it possible to conduct statistic analysis about the patterns of cumulative abnormal returns.[36] BVW propose several models for use in event studies each of which reflects different assumptions about the capitalization process. The method models the cumulative abnormal returns by a "diffusion process" that can be most conveniently represented by a deterministic differential equation plus a error term that is assumed to be iid (normal).[37] Because all the models included in their study imply an S-shaped cumulative abnormal return process (symmetric or non-symmetric) that incorporates the changing rate of time varying capitalization processes, the BVW method is able to estimate more conveniently the price effect around the announcement time when the price adjustment varies over time.

With daily data, the models presented in BVW and the model estimation procedure they proposed work better when the economic value of the event is translated into stock prices

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[36] The cumulative abnormal return at time t is the sum of abnormal returns up to time t, which is what BVW referred to as the "sum of abnormal return". BVW use the term "cumulative abnormal return" for a different kind of aggregation of abnormal returns, which will not be considered in this study.

[37] The "diffusion process" in BVW is adapted from the literature on product diffusion and technological innovation. Those diffusion processes are usually represented by a deterministic differential equation with an error term attached to capture the stochasticity. For a comprehensive survey on this type of diffusion processes, see Mahajan, Muller and Bass (1990). The term "diffusion process" in this study refers to a specific type of stochastic processes that can be represented by a stochastic integral with respect to a Brownian motion. For this type of diffusion processes, see, for example, Karatzas and Shreve (1991).

gradually.[38] When most economic value of an event is capitalized over only one or two days, such as in the case of many corporate takeovers,[39] estimation of the models in BVW encounters serious problems. The models in BVW can be estimated from either a differential equation or from the solution to the differential equation. When the price reaction is concentrated within one or two days, the estimation of the models based on the differential equation often understates the price effects. This is because the estimation merely treats the observation during the one or two days of sharp price reaction as outliers. On the other hand, the estimation of the solution to the differential equation involves a different kind of problem. When the price jumps in response to the event in one or two days, the cumulative abnormal return on those days exhibits jumps. In this case, there could be many S-shaped curves that fit the daily observations equally well and they can only be distinguished within the range where the observations exhibit quick jumps. However, there is usually no data in the range of the jump to identify which curve is the best one. This is a typical situation in which the daily observations are insufficient to identify the non-linear structure of the model so that the estimation fails.[40] Therefore, the estimation based on either the differential equation or the solution to the differential equation do not produce satisfactory results.[41]

The segmented diffusion model developed in Chapter 2 can overcome the estimation problems encountered in BVW. In the segmented diffusion model, the estimation problems in BVW are dealt

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[38] For example, market responses to many types of regulatory change often take place over a period longer than just a few days. The case in BVW is of this type.

[39] Dodd and Ruback (1977), Dodd (1980), Asquith (1983), Huang and Walkling (1987) and Jarrell and Poulsen (1989), for example, report in detail the cumulative abnormal returns of the target firms around the announcement time. They found that a more than 50 per cent price adjustment is realized at the announcement date.

[40] However, if intra-day observations are used, then the identification problem may not arise.

[41] The under-estimation problem and the identification problem will be discussed further in the next section in the context of our model.

with by estimating a system of two equations including both the differential equation and the solution to the differential equation at once. By so doing, each equation compensates the other for its weakness so that the under-identification problems are overcome. Since the two equations are to be estimated simultaneously and they are related to each other in a specific form (one is derived from the other, but they are not linearly dependent), the error terms specification of the two equations should be consistent with their structural relationship. The dynamic specification of an Ito process offers such a benefit of consistency in model specification and yet the structure is tractable enough for conducting empirical analysis.

3.3 Estimation of the Segmented Diffusion Model

We now present the estimation procedure of the segmented diffusion model. Recall that the segmented diffusion model developed in Chapter 2 is represented by:

$$dCAR_t = \begin{cases} \alpha CAR_t dt + \sigma dW_t , & t < t_0 \\ \beta(\hat{CAR}^* - CAR_t) dt + \sigma dW_t , & t \geq t_0 \end{cases} \tag{9}$$

Proposition 2 in Chapter 2 shows that the solution to the stochastic differential equation (9) is:

$$CAR_t = \begin{cases} \mu^- \hat{CAR}^* e^{\alpha(t-t_0)} + \sigma \int_{t_0}^{t} e^{\alpha(t-s)} dW_s , & t < t_0 \\ \hat{CAR}^* - (1-\mu)\hat{CAR}^* e^{-\beta(t-t_0)} + \sigma \int_{t_0}^{t} e^{-\beta(t-s)} dW_s , & t \geq t_0 \end{cases} \tag{10}$$

where t_0 is the announcement time; μ^- is the price run-up prior to the announcement; μ is the price run-up prior to and including the announcement; α and β are the rates of price run-up before and after the announcement; and $\hat{CAR}^*$ is the expected total cumulative abnormal return over the entire event period.

For the purpose of statistical inference, one can estimate either equation (9) or equation (10), depending on the nature of the event and the focus of the event study. If the parameter μ^- or μ are not of concern, and/or if the price reaction to the event is gradual (meaning the price adjustment to the event takes place over a period of many days), such as in the case of certain regulatory changes, equation (9) is often preferred and the estimation is conducted through some discrete approximation of equation (9). This is because the discrete approximation of equation (9) is linear in structure which offers advantages in estimation. However, if the parameter μ^- or μ is of concern or if the price reaction is sharp, estimation based on equation (9) cannot serve the needs. This is because that, first, equation (9) does not contain neither parameter μ^- or μ, and second, when the price reaction to the event is sharp (meaning the price adjustment to the event concentrates mainly on one or to days), estimation using equation (9) often fails to reflect the magnitude of the abnormal returns around the announcement time. Typically, it understates the announcement effect.[42] Therefore, it is necessary to use of equation (10) for estimation. Unfortunately, under the circumstance of sharp price effects, estimating equation (10) alone could also be troublesome. This is because the daily observations of stock returns could be insufficient to identify the non-linear structure of equation (10). For example, in the case of corporate takeovers, the cumulative abnormal returns to the target firm observed from a daily time series usually exhibit a sudden jump at the takeover announcement time. Under these circumstances, there could be a range of parameters α and β for equation (10) that produce significant structural differences only near the range of the jump where there is not enough observations available to distinguish one from the others. As a result, they all fit the daily time series equally well. This is what we referred earlier as the identification problem encountered

[42] When the major price adjustments appear within one or two days, the abnormal returns on those days will be treated as outliers comparing them with the rest observations over the estimation period (somewhere from 20 to 60 days). Thus the announcement effect is underestimated.

by BVW.

A general method using daily observations to estimate the cumulative abnormal return process around the announcement time should have several features: 1) It should be able to estimate all the model parameters including μ^- and μ; 2) It should be able to deal with the under estimation problem when the announcement effect is sharp; 3) It should also be able to deal with the identification problem associated with the sharp price reaction to the event.

The proposed approach is to deal with all three problems together by estimating a system of simultaneous equations consisting of a discrete approximation of both equation (9) and equation (10). To present the discrete time model, let us first discretize the continuous time. Consider an event period beginning at date -T and ending at date T. Date 0 is the last trading day before the takeover announcement. Date 1 is the first trading day following the date 0. Therefore, $0 < t_0 \leq 1$. Let us further define:

$$\Delta CAR_t = \begin{cases} CAR_{t+1} - CAR_t \ , \ t = -T,\ldots,-1 \\ CAR_t - CAR_{t-1} \ , \quad t = 1,\ldots,T \end{cases} \tag{11}$$

and

$$\begin{aligned} \varepsilon_{1t} &= \begin{cases} \sigma(W_{t+1} - W_t) \ , \ t = -T,\ldots,-1 \\ \sigma(W_t - W_{t-1}) \ , \quad t = 1,\ldots,T \end{cases} \\ \varepsilon_{2t} &= \begin{cases} \sigma\int_0^t e^{\alpha(t-s)} dW_s \ , \ t = -T,\ldots,-1 \\ \sigma\int_0^t e^{-\beta(t-s)} dW_s \ , \quad t = 1,\ldots,T \end{cases} \end{aligned} \tag{12}$$

Then, a discrete approximation of the segmented diffusion process can be written as a system of equations:

$$\Delta CAR_t = \begin{cases} \alpha CAR_t + \varepsilon_{1t}\,, & t = -T,\ldots,-1 \\ \beta(\hat{CAR}^* - CAR_t) + \varepsilon_{1t}\,, & t = 1,\ldots,T \end{cases}$$
$$CAR_t = \begin{cases} \mu_0 \hat{CAR}^* e^{\alpha t} + \varepsilon_{2t}\,, & t = -T,\ldots,-1 \\ \hat{CAR}^* - (1 - \mu_1)\hat{CAR}^* e^{-\beta t} + \varepsilon_{2t}\,, & t = 1,\ldots,T \end{cases} \tag{13}$$

where μ_0 is the price run-up up to the last day before the announcement (the date 0), and μ_1 is the price run-up up to the first day following the date 0. We call this system of equations (13) the segmented diffusion model to distinguish from the not approximated segmented diffusion process specified by equation (9) or equation (10).

In this approach, the missing parameters and underestimation problem which we discussed above are dealt with by the inclusion of the discrete version of equation (10), which is the second equation in the system of equations (13). The third issue of identification problem is dealt with by the inclusion of the discrete approximation of equation (9) that linearizes the non-linear structure between observations, which is the first equation in the system of equations (13).

For statistical inference, we estimate the model parameters of the system of equations (13) by using constrained maximum likelihood estimation. We first demonstrate that the error terms of the system of equations (13) have a multivariate normal distribution (theorem 1). Then we derive the maximum likelihood estimation of model parameters (theorem 2).

Theorem 1:

Let

$$\eta' = (\varepsilon_{1,-T},\ldots,\varepsilon_{1,-1},\varepsilon_{1,1},\ldots,\varepsilon_{1,T},\varepsilon_{2,-T},\ldots,\varepsilon_{2,-1},\varepsilon_{2,1},\ldots,\varepsilon_{2,T})' \tag{14}$$

then for $\alpha > 0$ and $\beta > 0$,

$$\eta \sim N(0,\sigma^2\Omega) \tag{15}$$

where

$$\Omega = \begin{bmatrix} I_{2T} & U_{2T} \\ U'_{2T} & V_{2T} \end{bmatrix} \tag{16}$$

$$U_{2T} = \begin{bmatrix} -(\frac{1-e^{-\alpha}}{\alpha})A_T & 0_T \\ 0_T & (\frac{1-e^{-\beta}}{\beta})B_T \end{bmatrix}, \qquad V_{2T} = \begin{bmatrix} (\frac{1-e^{-2\alpha}}{2\alpha})A'_T A_T & 0_T \\ 0_T & (\frac{1-e^{-2\beta}}{2\beta})B'_T B_T \end{bmatrix} \tag{17}$$

and A_T and B_T are full rank triangle matrices with the elements $a_{i,j}$ and $b_{i,j}$ given by:

$$a_{i,j} = \begin{cases} e^{-(i-j)\alpha}, & i \geq j \\ 0, & i < j \end{cases}$$
$$b_{i,j} = \begin{cases} e^{-(j-i)\beta}, & i \leq j \\ 0, & i > j \end{cases} \tag{18}$$

Proof. See appendix.

Theorem 1 affirms that the error terms of the system of equations (13) have a multivariate normal distribution. Thus we can apply the non-linear full information maximum Likelihood (NLFIML) estimation to the system of equations. The likelihood function for the system of equations (13) is:

$$\begin{aligned} &f(\alpha,\beta,\mu_0,\mu_1,C\hat{A}R^* \mid CAR_t,\Delta C\hat{A}R^*, t=-T,\ldots,T) \\ &= |J|(2\pi)^{-2T}|\sigma^2\Omega|^{-1/2}\exp(-\frac{1}{2\sigma^2}\eta'\Omega^{-1}\eta) , \end{aligned} \tag{19}$$

where

$$J = \begin{vmatrix} I_{2T} & H_{2T} \\ 0_{2T} & I_{2T} \end{vmatrix}, \quad H_{2T} = \begin{bmatrix} -\alpha I_T & 0_T \\ 0_T & \beta I_T \end{bmatrix}. \tag{20}$$

It is customary in estimation to use a concentrated likelihood function to reduce the number of parameters to be estimated.[43] The concentrated log likelihood function with respect to σ^2 is:

$$L(\alpha,\beta,\mu_0,\mu_1,C\hat{A}R^*) = -\frac{1}{2}\log|\Omega| - 2T\log(\eta'\Omega^{-1}\eta) \tag{21}$$

Theorem 2:

For $\alpha > 0$ and $\beta > 0$, Ω is positive definite, and hence $|\Omega| > 0$ and $\eta'\Omega^{-1}\eta > 0$. In addition,

$$|\Omega| = \left[\frac{1-e^{-2\alpha}}{2\alpha} - \left(\frac{1-e^{-\alpha}}{\alpha}\right)^2\right]^T \left[\frac{1-e^{-2\beta}}{2\beta} - \left(\frac{1-e^{-\beta}}{\beta}\right)^2\right]^T, \tag{22}$$

and, defining $\varepsilon_{2,0} = 0$, then

$$\begin{aligned} \eta'\Omega^{-1}\eta = & \sum_{t=-T}^{-1} \varepsilon_{1t}^2 + \left[\frac{\alpha}{2}\left(\frac{1+e^{-\alpha}}{1-e^{-\alpha}}\right) - 1\right]^{-1} \sum_{t=-T}^{-1} \left(\varepsilon_{1t} + \frac{\alpha}{1-e^{-\alpha}}\varepsilon_{2t} - \frac{\alpha e^{-\alpha}}{1-e^{-\alpha}}\varepsilon_{2,t+1}\right)^2 \\ & + \sum_{t=1}^{T} \varepsilon_{1t}^2 + \left[\frac{\beta}{2}\left(\frac{1+e^{-\beta}}{1-e^{-\beta}}\right) - 1\right]^{-1} \sum_{t=1}^{T} \left(\varepsilon_{1t} - \frac{\beta}{1-e^{-\beta}}\varepsilon_{2t} + \frac{\beta e^{-\beta}}{1-e^{-\beta}}\varepsilon_{2,t-1}\right)^2 \end{aligned} \tag{23}$$

Proof. See appendix.

Theorem 2 ensures that the concentrated log likelihood function (21) is well defined. To estimate the model parameters α, β, μ_0, μ_1 and $C\hat{A}R^*$, one can use NLFIML estimation that maximizes equation (21) subject to the defining constraint $\varepsilon_{2,0} = 0$.

We now discuss the properties of the NLFIML estimator. Let

[43] For some relevant discussion on this issue, see Amemiya (1985, Chapter 8), or Judge et al. (1985) for mare general discussions.

$\kappa = (\alpha\ , \beta\ , \mu_0\ , \mu_1\ , \hat{CAR}^*)'$. Denote $\hat{\kappa}$ the NLFIML estimator of κ and κ_0 the true value of κ. If η is multivariate normal, Amemiya (1977) show that $\hat{\kappa}$ is consistent, asymptotically normal and in general has a smaller asymptotic covariance matrix than the nonlinear three-stage least square estimators. That is,

$$(2T)^{\frac{1}{2}}(\hat{\kappa}-\kappa_0) \rightarrow N(0, -P\lim \frac{1}{2T}\left[\frac{\partial^2 L}{\partial\kappa\partial\kappa'}\Big|_{\kappa=\kappa_0}\right]^{-1}) \tag{24}$$

For hypothesis testing, we can compute the asymptotic t-value (the estimated κ divided by its estimated asymptotic standard deviation). Under the null hypothesis that $\kappa_0 = 0$, the asymptotic t-value follows a t-distribution. Thus we can carry out statistical inference.

3.4 Implications

The segmented diffusion model developed in Chapter 2 can be applied to event studies other than corporate takeovers. Empirical evidence indicates that for many events, the economic value of the event is capitalized gradually at a changing rate.[44] In these type of capitalization processes, the stock price adjustment gradually starts somewhere before the announcement of the event, then gradually increases at an increasing rate. After the adjustment reaches a certain level, usually around the announcement time, the adjustment slows down and eventually ceases out. In terms of cumulative abnormal returns, this type of capitalization processes exhibits an S-shaped pattern with the inflection point occurring somewhere around the announcement time. The segmented diffusion model captures a class of capitalization processes whose cumulative abnormal return exhibits a S-

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[44] Dodd and Ruback (1977) and Jarrell and Poulsen (1989), for example, have shown it to be the case for some mergers and acquisitions. Barclay and Litzenberger (1988) have shown it to be the case for some new equity issues. Masulis and Korwar (1986) have shown it to be the case for some seasoned equity offerings. Patell (1976) has shown it to be the case for some corporate forecasts of earnings. Boardman, Vertinsky and Whistler (1992), and Smith, Bradley, and Jarrell (1986) have also shown it to be the case for some regulatory changes.

shape.

However, the application of the segmented diffusion model goes beyond events of which the cumulative abnormal returns exhibits an increasing S-shaped pattern. For $\alpha > 0$, $\beta > 0$, the case when $\hat{CAR}^* > 0$, $\mu_0 > 0$ and $\mu_1 > 0$ describes the event of positive abnormal returns. When $\hat{CAR}^* < 0$, $\mu_0 > 0$ and $\mu_1 > 0$ describes the event of negative abnormal returns. In particular, when $\mu_1 > 1$, the process exhibits over-shooting during the announcement date and returning back to $\hat{CAR}^*$ after the announcement date.

More importantly, the segmented diffusion model captures both gradual and dramatic, anticipated and unanticipated events. For (unanticipated) events with dramatic price effects, $\alpha \to 0$, $\beta > 0$ and $\mu_0 \to 0$. For anticipated events, then $\alpha > 0$ and $\mu_0 > 0$. If the price effect is dramatic, $\mu \approx 1$. When $\alpha = \beta$ and $\mu_0 = \mu_1 = \frac{1}{2}\hat{CAR}^*$, the model is symmetric similar to the logistic model described in BVW.

3.4.1 Comparison with alternative methods

One of the greatest advantage of the segmented diffusion model is its application to the time-varying capitalization processes. In contrast with the CRGP method, the segmented diffusion model can estimate when the event actually starts and when it finishes. Thus it simplifies the estimation of the CRGP in dealing with the time-varying capitalization processes. In contrast with the BVW method, the segmented diffusion model cannot only accommodate a gradually changing rate of price adjustment without introducing a large number of parameters, but also overcomes the under-estimation problem and the identification problem encountered in BVW when the announcement effect is sharp.

When the price reaction to the event is sharp, the rate of capitalization before and after the announcement could be significantly different, although the process can still exhibit an S-shaped pattern. It is well understood that the price adjustment reflects new information available to investors. When the announcement of the event comes as a surprise and the information content of the announcement is substantial, the price adjustment process following the announcement could be very different from the previous one. Consequently, the patterns of the cumulative abnormal returns could switch from one form to the another before and after the announcement. The segmented diffusion model incorporates the possibility of a sudden switch in the rate of the capitalization before and after the announcement. Thus it allows one to analyze differences in price reactions before and after the announcement. By contrast, the models in BVW is not flexible enough to capture a dramatic switch in the pattern of cumulative abnormal returns, although they cover some non-symmetric S-shaped cumulative abnormal return processes.

The model also allows us to compare the level of capitalization up to the announcement or the level of capitalization immediately after the announcement with the level of capitalization over the entire event period $C\hat{A}R^*$. This comparison is described by the parameters μ_0 and μ_1. In the case of mergers and acquisitions, this comparison allows us to make inferences on information leakage or insider trading.

3.4.2 Comparison between two events

A distinct feature of this thesis is to analyze the effects of changing regulations and the effects of takeover announcements at the same time. A methodology that captures the effects of regulatory changes on price run-up during takeovers is not immediately available.[45] This section demonstrates

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[45] Malatesta and Thompson (1993) investigate changes in the announcement effect of a sample of takeovers before and after the Williams Act. However, they do not look at a partition between announcement effect and run-up.

one application of the segmented diffusion model that can achieve such a goal. This application is discussed in a more general context of comparing the difference between two types of events.

Let subscript 1 denote type 1 events and subscript 2 type 2 events. Then we obtain a system of four equations:

$$
\begin{aligned}
\Delta CAR_{1t} &= \begin{cases} \alpha_1 CAR_{1t} + \varepsilon_{1t} , & t = -T,\ldots,-1 \\ \beta_1 (\hat{CAR}_1^* - CAR_{1t}) + \varepsilon_{1t} , & t = 1,\ldots,T \end{cases} \\
CAR_{1t} &= \begin{cases} \mu_{01} \hat{CAR}_1^* e^{\alpha_1 t} + \varepsilon_{2t} , & t = -T,\ldots,-1 \\ \hat{CAR}_1^* - (1 - \mu_{11}) \hat{CAR}_1^* e^{-\beta_1 t} + \varepsilon_{2t} , & t = 1,\ldots,T \end{cases} \\
\Delta CAR_{2t} &= \begin{cases} \alpha_2 CAR_{2t} + \varepsilon_{3t} , & t = -T,\ldots,-1 \\ \beta_2 (\hat{CAR}_2^* - CAR_{2t}) + \varepsilon_{3t} , & t = 1,\ldots,T \end{cases} \\
CAR_{2t} &= \begin{cases} \mu_{02} \hat{CAR}_2^* e^{\alpha_2 t} + \varepsilon_{4t} , & t = -T,\ldots,-1 \\ \hat{CAR}_2^* - (1 - \mu_{12}) \hat{CAR}_2^* e^{-\beta_2 t} + \varepsilon_{4t} , & t = 1,\ldots,T \end{cases}
\end{aligned}
\tag{25}
$$

where $\varepsilon_{1,t}$, $\varepsilon_{2,t}$, $\varepsilon_{3,t}$ and $\varepsilon_{4,t}$ are defined accordingly

$$
\begin{aligned}
\varepsilon_{1t} &= \begin{cases} \sigma_1 (W_{t+1} - W_t) , & t = -T,\ldots,-1 \\ \sigma_1 (W_t - W_{t-1}) , & t = 1,\ldots,T \end{cases} \\
\varepsilon_{2t} &= \begin{cases} \sigma_1 \int_0^t e^{\alpha_1 (t-s)} dW_s , & t = -T,\ldots,-1 \\ \sigma_1 \int_0^t e^{-\beta_1 (t-s)} dW_s , & t = 1,\ldots,T \end{cases} \\
\varepsilon_{3t} &= \begin{cases} \sigma_2 (W_{t+1} - W_t) , & t = -T,\ldots,-1 \\ \sigma_2 (W_t - W_{t-1}) , & t = 1,\ldots,T \end{cases} \\
\varepsilon_{4t} &= \begin{cases} \sigma_2 \int_0^t e^{\alpha_2 (t-s)} dW_s , & t = -T,\ldots,-1 \\ \sigma_2 \int_0^t e^{-\beta_2 (t-s)} dW_s , & t = 1,\ldots,T \end{cases}
\end{aligned}
\tag{26}
$$

In addition, let us define the differences of the model parameters by:

$$
\begin{aligned}
\Delta\alpha &= \alpha_2 - \alpha_1 \\
\Delta\beta &= \beta_2 - \beta_1 \\
\Delta\mu_0 &= \mu_{02} - \mu_{01} \\
\Delta\mu_1 &= \mu_{12} - \mu_{11} \\
\Delta\hat{CAR}^* &= \hat{CAR}_2^* - \hat{CAR}_1^*
\end{aligned}
\tag{27}
$$

If we assume the two types of events are independent, then we can examine the differences of the model parameter by combined two time series of cumulative abnormal returns together to construct a nested log likelihood function. Since the two time series are independent, the nested concentrated log likelihood function of the pooled sample is simply the sum of the concentrated log likelihood function for the type 1 event and the concentrated log likelihood function for the type 2 event. If L^* denotes the concentrated log likelihood function of the pooled sample, then,

$$
\begin{aligned}
&L^*(\alpha_1,\beta_1,\mu_{01},\mu_{11},\hat{CAR}_1^*,\Delta\alpha,\Delta\beta,\Delta\mu_0,\Delta\mu_1,\Delta\hat{CAR}^*) \\
&= L(\alpha_1,\beta_1,\mu_{01},\mu_{11},\hat{CAR}_1^*) + L(\alpha_1+\Delta\alpha,\beta_1+\Delta\beta,\mu_0+\Delta\mu_0,\mu_1+\Delta\mu_1,\hat{CAR}_1^*+\Delta\hat{CAR}^*)
\end{aligned}
\tag{28}
$$

where L is given by equation (21).

To compare the differences between the two types of events, we estimate (28) by using a constrained optimization that maximizes L^* subject the defined constraint $\varepsilon_{2,0} = 0$ and $\varepsilon_{4,0} = 0$. The parameters $\Delta\alpha$, $\Delta\beta$, $\Delta\mu_0$, $\Delta\mu_1$ and $\Delta\hat{CAR}^*$ provides us with estimated differences between the two events. The comparison allows us to make inferences on whether the difference appears before or after the announcement, i.e., whether $\Delta\alpha$ is greater than $\Delta\beta$ or whether $\Delta\mu_0$ is greater than $\Delta\mu_1$. It is also allows us to make inferences on whether the difference before and after the announcement is pointing to the same direction, i.e., whether the signs of $\Delta\alpha$ and $\Delta\beta$ are the same, or whether the signs of $\Delta\mu_0$ and $\Delta\mu_1$ are the same.

Chapter 4 will demonstrate one application of this comparison in the context of studying regulatory changes.

4.5 Conclusion

This chapter demonstrates the estimation of the segmented diffusion model and the implications of the model. The segmented diffusion model is motivated by the needs of estimating a time-varying capitalization process. In contrast with other event study methodologies, the segmented diffusion model has advantages in dealing with continuing changing price adjustments over a long time period. The application of the model is rather general, it captures price reactions to both positive value and negative value economic events including regulatory changes and corporate events. It can also deal with either gradual price reactions or dramatic price reactions, anticipated or unanticipated events. It can also incorporate non-symmetric price adjustments around announcement time, and possible overshooting price adjustments.

More importantly, by combining different diffusion processes together one can analyze the effects of both regulatory changes and corporate events. Even when regulatory changes take place gradually over a long time horizon and corporate events take place in a few days, a system combining two segmented diffusion models allows one to estimate directly both the regulatory effects and the effects of corporate events and to make meaningful statistical inferences.

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3.7 Appendix: Proof of Theorems

3.7.1 Proof of Theorem 1.

Let t_i^n be a partition over $[-T, T]$ such that $t_i^n \in [t_0 - T, t_0 + T]$, $t_i^n < t_{i+1}^n$, $i = 0,1,\ldots,n$. Defining:

$$\Delta W_{t_i^n} = W_{t_i^n} - W_{t_{i-1}^n}$$

$$\varepsilon_{1t}^n = \begin{cases} \sigma \sum\limits_{t_i^n \in [t,t+1]} \Delta W_{t_i^n}, & t = -T,\ldots,-1 \\ \sigma \sum\limits_{t_i^n \in [t-1,t]} \Delta W_{t_i^n}, & t = 1,\ldots,T \end{cases}$$

$$\varepsilon_{2t}^n = \begin{cases} \sigma \sum\limits_{t_i^n \in [-T,0]} e^{\alpha(t-t_i^n)} \Delta W_{t_i^n}, & t = -T,\ldots,-1 \\ \sigma \sum\limits_{t_i^n \in [0,t]} e^{-\beta(t-t_i^n)} \Delta W_{t_i^n}, & t = 1,\ldots,T \end{cases} \tag{29}$$

and

$$\eta_n' = (\varepsilon_{1,-T}^n, \ldots, \varepsilon_{1,-1}^n, \varepsilon_{1,1}^n, \ldots, \varepsilon_{1,T}^n, \varepsilon_{2,-T}^n, \ldots, \varepsilon_{2,-1}^n, \varepsilon_{2,1}^n, \ldots, \varepsilon_{2,T}^n)' \tag{30}$$

Let $\Delta W_n' = (\Delta W_{t_1^n}, \ldots, \Delta W_{t_n^n})'$. Then η_n is simply the linear combination of ΔW_n:

$$\eta_n = D_n \, \Delta W_n \tag{31}$$

Where D_n is a $n \times 4T$ matrix of rank $4T \le n$. By the property of Brownian motion, for every n, ΔW_n has a multivariate normal distribution. It follows that η_n has a multivariate normal distribution (Grimmett and Stirzaker (1988), p 69.). Let F be the distribution function of η and F^n be the distribution function of η_n. By construction, $\eta_n \to \eta$ in probability as $n \to \infty$. By the property of vague convergence, $F^n \to F$ in distribution (Chung (1974), p 92, theorem 4.4.5.). F^n is multivariate normal implies that F is multivariate normal.

We now proceed to calculate the mean and the covariance matrix of η. By the property of Brownian motion, $E\eta = 0$. For the variance-covariance among $\varepsilon_{1,t}$'s, the Brownian motion structure gives:

$$COV(\varepsilon_{1,t}, \varepsilon_{1,s}) = \begin{cases} \sigma^2, & t = s \\ 0, & t \neq s \end{cases}$$

This yields the upper diagonal block matrix I_{2T} in Ω.

For the variance-covariance among $\varepsilon_{2,t}$'s, consider three cases. Case 1: $0 \ge t \ge s$,

$$\begin{aligned} COV(\varepsilon_{2,t}, \varepsilon_{2,s}) &= E\left[\left(\sigma\int_0^t e^{\alpha(t-\tau)} dW_\tau\right)\left(\sigma\int_0^s e^{\alpha(s-\tau)} dW_\tau\right)\right] \\ &= \sigma^2 e^{\alpha(t+s)} \int_t^0 e^{-2\alpha\tau} d\tau \\ &= \left[\frac{\sigma^2}{2\alpha}\right] e^{-\alpha(t-s)}(1 - e^{2\alpha t}) \end{aligned} \tag{33}$$

Case 2: $t \geq s \geq 0$,

$$\begin{aligned} COV(\varepsilon_{2,t}, \varepsilon_{2,s}) &= E\left[\left(\sigma\int_0^t e^{-\beta(t-\tau)}dW_\tau\right)\left(\sigma\int_0^s e^{-\beta(s-\tau)}dW_\tau\right)\right] \\ &= \sigma^2 e^{-\beta(t+s)}\int_t^0 e^{2\beta\tau}d\tau \\ &= \left[\frac{\sigma^2}{2\beta}\right]e^{-\beta(t-s)}(1-e^{-2\beta s}) \end{aligned} \tag{34}$$

Case 3: $t \geq 0 \geq s$ or $t \leq 0 \leq s$,

$$COV(\varepsilon_{2,t}, \varepsilon_{2,s}) = 0$$

This yields the lower diagonal block matrix V_{2T} in Ω.

For the cross equation covariance, consider also three cases. Case 1: $0 > t \geq s$,

$$\begin{aligned} COV(\varepsilon_{1,t}, \varepsilon_{2,s}) &= E\left[\left(\sigma\int_t^{t+1} dW_\tau\right)\left(\sigma\int_0^s e^{\alpha(s-\tau)}dW_\tau\right)\right] \\ &= \sigma^2 e^{\alpha s}\int_t^{t+1} e^{-\alpha\tau}d\tau \\ &= -\left[\frac{\sigma^2}{\alpha}\right]e^{-\alpha(t-s)}(1-e^{-\alpha}) \end{aligned} \tag{36}$$

Case 2; $s \geq t > 0$,

$$\begin{aligned} COV(\varepsilon_{1,t}, \varepsilon_{2,s}) &= E\left[\left(\sigma\int_{t-1}^{t} dW_\tau\right)\left(\sigma\int_0^s e^{-\beta(s-\tau)}dW_\tau\right)\right] \\ &= \sigma^2 e^{-\beta s}\int_{t-1}^{t} e^{\beta\tau}d\tau \\ &= \left[\frac{\sigma^2}{\beta}\right]e^{-\beta(s-t)}(1-e^{-\beta}) \end{aligned} \tag{37}$$

Case 3: $t < s \leq 0$, $t < 0 \leq s$, $t > 0 \geq s$, or $t > s \geq 0$,

$$COV(\varepsilon_{1,t}, \varepsilon_{2,s}) = 0$$

This yields the off-diagonal block matrix U_{2T} in Ω. This completes the proof.

3.7.2 Proof of Theorem 2.

Let $f(x) = \frac{x}{2} - \frac{1 - e^{-x}}{1 + e^{-x}}$, we first show that for x>0, f(x)>0. Notice that

$$f'(x) = \frac{1}{2} - \frac{2e^{-x}}{2e^{-x} + (1 + e^{-2x})} \tag{39}$$

For x>0,

$$\begin{aligned} & (1 - e^{-x})^2 > 0 \\ \Rightarrow\ & 1 + e^{-2x} > 2e^{-x} \\ \Rightarrow\ & \frac{1}{2} > \frac{2e^{-x}}{2e^{-x} + (1 + e^{-2x})} \\ \Rightarrow\ & f'(x) > 0 \end{aligned} \tag{40}$$

Since $f(x) \rightarrow 0$ as $x \rightarrow 0$, then for x>0, $f'(x) > 0$ implies that $f(x) > 0$.

Now, let u_{ij} denote the element of matrix U_{2T}. For $\alpha > 0$ and $\beta > 0$, define:

$$k = \begin{cases} \left[\frac{\alpha}{2}\frac{1+e^{-\alpha}}{1-e^{-\alpha}} - 1\right]^{\frac{1}{2}} & , \text{ if } u_{ij} = u_{ij}(\alpha) \\ \left[\frac{\beta}{2}\frac{1+e^{-\beta}}{1-e^{-\beta}} - 1\right]^{\frac{1}{2}} & , \text{ if } u_{ij} = u_{ij}(\beta) \end{cases} \tag{41}$$

The property of f(x) proved above ensures that k is well defined and k>0. From theorem 1 and by matrix decomposition:

$$\Omega = \begin{bmatrix} I_{2T} & U_{2T} \\ U'_{2T} & V_{2T} \end{bmatrix} = \begin{bmatrix} I_{2T} & U_{2T} \\ U'_{2T} & (1+k^2)U'_{2T}U_{2T} \end{bmatrix} = \begin{bmatrix} I_{2T} & 0_{2T} \\ U'_{2T} & kU'_{2T} \end{bmatrix} \begin{bmatrix} I_{2T} & U_{2T} \\ 0_{2T} & kU_{2T} \end{bmatrix} \tag{42}$$

From equation (17) and (18), it is easy to see that Ω has a full rank. Since Ω can be decomposed into the product of a matrix and its transpose, it is positive definite. It follows from theorem 1 that

$$
\begin{aligned}
|\Omega| &= |\ V_{2T} - U_{2T}'U_{2T}\ | \\
&= \begin{vmatrix} (\frac{1-e^{-2\alpha}}{2\alpha} - (\frac{1-e^{-\alpha}}{\alpha})^2)A_T'A_T & 0_T \\ 0_T & (\frac{1-e^{-2\beta}}{2\beta} - (\frac{1-e^{-\beta}}{\beta})^2)B_T'B_T \end{vmatrix} \\
&= \left[\frac{1-e^{-2\alpha}}{2\alpha} - \left(\frac{1-e^{-\alpha}}{\alpha}\right)^2\right]^T \left[\frac{1-e^{-2\beta}}{2\beta} - \left(\frac{1-e^{-\beta}}{\beta}\right)^2\right]^T
\end{aligned} \tag{43}
$$

Furthermore, it follows from (42) that,

$$
\Omega^{-1} = \begin{bmatrix} I_{2T} & -\frac{1}{k}I_{2T} \\ 0_{2T} & \frac{1}{k}U_{2T}^{-1} \end{bmatrix} \begin{bmatrix} I_{2T} & 0_{2T} \\ -\frac{1}{k}I_{2T} & \frac{1}{k}U_{2T}'^{-1} \end{bmatrix} \tag{44}
$$

where,

$$
U_{2T}^{-1} = \begin{bmatrix} -(\frac{\alpha}{1-e^{-\alpha}})A_T^{-1} & 0_T \\ 0_T & (\frac{\beta}{1-e^{-\beta}})B_T^{-1} \end{bmatrix} \tag{45}
$$

$$
A_T^{-1} = \begin{bmatrix} 1 & 0 & \cdots & \cdots & \cdots & 0 \\ -e^{-\alpha} & 1 & \ddots & \ddots & \ddots & \vdots \\ 0 & -e^{-\alpha} & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & -e^{-\alpha} & 1 & 0 \\ 0 & \cdots & \cdots & 0 & -e^{-\alpha} & 1 \end{bmatrix} \tag{46}
$$

$$B_T^{-1} = \begin{bmatrix} 1 & -e^{-\beta} & 0 & \cdots & \cdots & 0 \\ 0 & 1 & -e^{-\beta} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & -e^{-\beta} & 0 \\ \vdots & \ddots & \ddots & \ddots & 1 & -e^{-\beta} \\ 0 & \cdots & \cdots & \cdots & 0 & 1 \end{bmatrix} \tag{47}$$

Define $\varepsilon_i' = (\varepsilon_{i,t_0-T}, \ldots, \varepsilon_{i,t_0+T})'$ for i=1,2, and $\varepsilon_{2,0} = 0$. Then,

$$\begin{aligned} \eta'\Omega^{-1}\eta &= (\varepsilon_1' \quad \varepsilon_2') \begin{bmatrix} I_{2T} & -\frac{1}{k}I_{2T} \\ 0_{2T} & \frac{1}{k}U_{2T}^{-1} \end{bmatrix} \begin{bmatrix} I_{2T} & 0_{2T} \\ -\frac{1}{k}I_{2T} & U_{2T}'^{-1} \end{bmatrix} \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \\ &= (\varepsilon_1' \quad -\frac{1}{k}\varepsilon_1' + \frac{1}{k}\varepsilon_2' U_{2T}^{-1}) \begin{bmatrix} \varepsilon_1 \\ -\frac{1}{k}\varepsilon_1 + \frac{1}{k}U_{2T}'^{-1}\varepsilon_2 \end{bmatrix} \\ &= \varepsilon_1'\varepsilon_1 + \frac{1}{k^2}(\varepsilon_1 - U_{2T}'^{-1}\varepsilon_2)'(\varepsilon_1 - U_{2T}'^{-1}\varepsilon_2) \\ &= \sum_{t=-T}^{-1}\varepsilon_{1t}^2 + \left[\frac{\alpha}{2}\left[\frac{1+e^{-\alpha}}{1-e^{-\alpha}}\right] - 1\right]^{-1} \sum_{t=-T}^{-1}\left[\varepsilon_{1t} + \frac{\alpha}{1-e^{-\alpha}}\varepsilon_{2t} - \frac{\alpha e^{-\alpha}}{1-e^{-\alpha}}\varepsilon_{2,t+1}\right]^2 \\ &\quad + \sum_{t=1}^{T}\varepsilon_{1t}^2 + \left[\frac{\beta}{2}\left[\frac{1+e^{-\beta}}{1-e^{-\beta}}\right] - 1\right]^{-1} \sum_{t=1}^{T}\left[\varepsilon_{1t} - \frac{\beta}{1-e^{-\beta}}\varepsilon_{2t} + \frac{\beta e^{-\beta}}{1-e^{-\beta}}\varepsilon_{2,t-1}\right]^2 \end{aligned} \tag{48}$$

This completes the proof.

Chapter Four

EMPIRICAL EVIDENCE ON THE EFFECTS OF REGULATORY CHANGES

4.1 Introduction

This chapter applies the models developed in the earlier chapters to conduct an empirical analysis of the effect of regulatory change on illegal insider trading and stock price movements. To assess the impact of regulatory changes, we compare price movements during takeovers (characterized by the cumulative abnormal returns to targets) during two different regulatory regimes. The first period, between 1982-1984, is characterized by lax regulations and the second period, between 1988-1991, is characterized by tight regulations. From differences in price movements between these two regulatory regimes, we make inferences about information revelation, illegal insider trading and the effectiveness of regulatory changes.

In this chapter we discuss first sample construction and data preparation. In sample construction, we focus on factors that are likely to induce price reactions not due to the effects of regulatory changes so that we can attribute changes in price movements to the changes in regulations. Specifically, we control for impacts associated with sectoral differences and other takeover related characteristics by imposing several sample selection criteria that would presumably control for major influences other than regulatory changes on prices. These criteria include the choice of the industry, the choice of the takeover event, the choice of the takeover target, and the interplay between the acquiring firm and the target during the takeover.

We select six industries that are most active in corporate takeovers over the two periods between 1982-1984 and between 1989-1991. For the takeover targets that satisfy our sample selection criteria, we further classify them into two categories: negotiated takeovers and takeovers initiated by bidding.

In section 4.4, we test the three hypotheses that were presented in Chapter 2. Hypothesis I deals jointly with information revelation and the effectiveness of regulatory changes. We find that the tightening of insider trading regulations in the 1980's was effective and inside information was partially revealed to the market. Hypothesis II concerns whether the regulatory changes had more impact on insider trading during negotiated takeovers than on insider trading during takeovers initiated by bidding. The evidence suggest that regulatory changes had a greater impact on negotiated takeovers than on takeovers initiated by bidding. Hypothesis III deals with whether insiders associated with acquiring firms or groups seek fewer but more profitable takeovers after the introduction of tighter regulations. We find weak evidence of this Hypothesis.

The rest of the chapter is organizes as follows. Section 4.2 elaborates on our sample selection criteria and the procedure of sample construction. Section 4.3 discuss the measurement of price changes in light of the segmented diffusion model developed in Chapter 2, including some empirical justification for the dynamic specification of the segmented diffusion model. Section 4.4 presents our empirical results. Finally, section 4.5 provides conclusion.

4.2 Sample Construction

Our central concern in this empirical study is to analyze changes in price movements during takeovers affected by regulatory changes designed to reduce the level of illegal insider trading. This is achieved by comparing price movements of takeover targets selected from two disjoint time periods. The period of 1982-1984 is referred to as a period of lax regulations, and the period of 1989-1991 as a period of tight regulations. The justification of making this particular segmentation of time series is provided in Chapter 1.

4.2.1 Sampling criteria

To examine the differences in stock prices due to regulatory changes, it is vital to control for other impacts associated with stock prices attributed to sectoral differences and other takeover related characteristics that are likely to induce price effects. To deal with sectoral differences, we concentrate on a small number of industries and match them across the two regulatory regimes. At the same time, we need to have a sample size that is sufficiently large for conducting meaningful statistical analysis. For the above reasons, we select six industries that were most extensively involved in corporate takeovers during the two periods we study. They include Banking and Fiance (SIC code: 6000's and 6100's), Food and Beverage (SIC code: 2000's), Investment (SIC code: 6711 and 6712), Insurance (SIC code: 6300's and 6411), Oil and Gas (SIC code: 1311, 1380's, 2900's and 4920's), and Retail (SIC code: 5200's-5700's and 5900's).[46]

The takeover related characteristics concern the nature of the takeover and the interplay between the target and the acquiring firm during the process of takeover. All of these factors may trigger different reactions in the target firm stock price during takeovers. Specifically, we consider only successful takeovers valued over \$100 millions.[47] By a successful takeover we mean an

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[46] As will be specified later, we consider only successful takeovers with transaction size over \$100 million. According to the source from the "\$100-million-plus transactions industry breakdown" in the Mergerstat Review (MR), we select six industries with the highest ranking in terms of number of transactions over \$100 million cumulated over the years 1982-1984 and 1989-1991. The "Food and Beverage" in our sample includes the Food Processing and Beverages in the MR. The" Oil and Gas" includes the Oil & Gas and a part of the Electric, Gas, Water & Sanitary Services in the MR. The "Investment" includes the Brokerage, Investment & Mgmt Consulting and a part of the Conglomerate in the MR. The rest three industries in our sample are classified as the same by the MR. Industries under the name appeared in the MR correspond to a wider range of SIC codes than those used in our sample. To balance the size of six industry portfolios, we reduce the range of some industries' SIC codes specified by the MR to a narrower range by deleting only those ranges of SIC codes that do not cover any SIC code of the takeover target in our sample.

[47] Several empirical studies document that cumulative average abnormal returns to the target of unsuccessful takeovers exhibit a different patten than the one of successful takeovers (Bradley (1980), Dodd (1980), Asquith (1983), Bradley, Desai and Kim (1983), Samuelson and Rosenthal (1986)). We separate the two types takeovers and focus on the successful ones only. The choice for the transaction over \$100 million is motivated by the concern that the size of abnormal returns may be related with the value of the firm.

acquisition of an independently listed company completed by December 31, 1991.[48] An acquisition of a partial stake in a target without previously owning all the rest of stakes is not considered as a takeover. In addition, we also exclude the acquisition of a stake in a target that is less than 30 percent, even though the acquirer may have already own the rest of stakes in the target.[49] The targets chosen are limited to U.S. firms, but there is no such restriction on the acquiring firms.[50]

With regards to pre-announcement price movements, there are several factors that could produce significant price effects not due to insider trading. For instance, takeover war among suitors often induces strong price reaction.[51] To avoid this problem, we exclude target firms involved in takeover wars immediately before the announcement of the successful takeover. Based on the sources of the Wall Street Journal Index (WSJI) and the New York Times Index (NYTI), we exclude cases in which there were other takeover attempts being reported within two months prior to the successful one.[52] Cases in which a takeover target seeks openly for a buyer in the takeover market

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[48] The independent listing requirement precludes the acquisitions of an entire subsidiary or an entire sub-division that is not listed on any stock exchange, simply because there is no information about the stock prices for these firms.

[49] The 30 percent requirement is to rule out acquisitions that are not big enough to produce significant impact on stock prices of the target.

[50] We do not consider the difference between domestic takeovers and international takeovers. Although there might be some differences associated with target returns (Harris and Ravenscraft (1991) and Kang 1993), the difference seem to have more effect on the premia than on the possible information leakage. We limit ourselves to U.S. firms because they are subject to the same disclosure requirements so that the price effects of unanticipated news such as takeover announcement would be similar.

[51] Takeover war among suitors prior to a successful takeover involves a series takeover announcements and revisions in offering prices for the takeover target. These incidence result in a series price adjustments that may be dominated by the incidence rather than insider trading.

[52] Empirical evidence seems to suggest that the revision to a takeover announcement sustains for a rather long period following the announcement. Dodd (1980) and Asquith (1983) report that, in the case of unsuccessful takeovers, the cumulative average abnormal returns to the target resulted from the announcement persist until the cancelation date of the takeover. Bradley, Desai and Kim (1988) report that, in the case of unsuccessful takeovers, the cumulative average abnormal returns to the target resulted from the announcement disappear eventually after approximately six months when there is no further takeover attempts in the subsequent period. However, the cumulative average abnormal returns persist when the target is subsequently taken over within

before any potential acquirer making the takeover attempt are also excluded. Specifically, we do not consider those cases in which the target firm put itself on sale within two months before the announcement of a successful takeover.[53] Target firms whose stock is suspended from regular trading within 10 trading days before and during the event period is also excluded, as the suspension is likely to result in significant price adjustments not necessarily induced by the takeover event.[54]

There are also other takeover related characteristics that are empirically documented to have affects on target returns. Among them, the most noted ones are the method of payments, tender offers versus mergers, and friendly takeovers versus hostile takeovers.[55] These characteristics, however, affect mostly the takeover premia earned by the target firm which is related to post-announcement price movements. They do not seem to related to any pre-announcement price movements.[56] As our study focus on the pre-announcement price movements, we do not consider these takeover related characteristics.

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sixty days. Unfortunately, this evidence dose not offer clearly how long it takes to eliminate the price effects from a previous takeover attempt if the target is in the end taken over successfully. Thus we choose arbitrarily the two-month elapse as a sample selection criterion. We believe that the major effect of a rival bid occurs at the time the bid is announced. Thus, as long as there is no rival bids appear during the period we study, we have avoided the major effect of a rival bid.

[53] As the target conveys its intention in public of going for a merger, its stock price may start to climb.

[54] Suspending stocks from trading often associated with major on-going corporate events. If suspension of target stocks from trading is due to other corporate events occurred during the takeover period, then we might have several events clustering together each of which induces some price effects. As there are lacking sufficient sources to identify the reason for suspending target stocks from trading, we simply exclude the cases related to stock trading suspension.

[55] For example, Huang and Walkling (1987), Franks, Harris and Mayer (1988), Eckbo and Langohr (1989) and Eckbo, Giammarino and Heinkel (1990) document that the method of payments affects the takeover premium. Empirical evidence also suggests, for example, Jensen and Ruback (1983), that the abnormal returns to the merging firm may be smaller than to the target of tender offers. It is also suggested that, in a hostile takeover, the resistance from the target management may lead to the revision of the post announcement price of the target firm (Pound (1988)).

[56] For example, Jarrell and Poulsen (1989) find that there is no significant difference between friendly and hostile takeovers concerning the price run-up prior to takeover announcements.

4.2.2 Negotiated takeover versus takeovers initiated by bidding

As pointed out in Chapter 2, insider trading may be more extensively involved in negotiated takeovers. Therefore, we have further classified targets according to whether the takeover deal is initiated by secret negotiations or by an open offer. Negotiated takeovers are those takeovers resulting from a mutual agreement between the management of the target firm and the management of the acquiring firm prior to a public announcement of the takeover. Takeovers initiated by bidding are those start with an open bid by the acquiring firm without consulting with the target management prior to submitting the bid. Sources used to identify each type of takeovers are the Wall Street Journal (WSJ) and the New York Times (NYT) news reports regarding the takeover events. If the management of the two firms involved in a takeover deal have officially negotiated over the terms of the takeover transaction before the announcement, the takeover is considered as a negotiated takeover. This category includes takeovers negotiated following a secret bid. The resolution of the negotiation could be either a statutory merger or a tender offer. If, on the other hand, the two parties involved never meet each other officially concerning the takeover prior to the announcement, and a bid has already been made for the target prior to the announcement, then the takeover is considered as a takeover initiated by bidding. Reactions from the target management to the open bid could be either friendly or hostile. This category includes situations in which the biding firm and the target firm later engage in official negotiations following the initial public announcement of the bid. Again, the resolution of the negotiations could be either a statutory merger or a tender offer.

4.2.3 Data and sampling result

Takeover targets were identified from the 100 Million Dollar Club in the annual report of Mergerstat Review (MR) published by the Merrill Lynch Business Brokerage and Valuation. To obtain information on stock prices, the target must be listed on either the New York Stock Exchange (NYSE), or on the American Stock Exchange (AMEX), or on the National Association of Securities Dealers Automatic Quotation system (NASDAQ) for a period of at least 15 trading days before and after the takeover announcement. The overall 31 trading day event period must lie either in the period from January 4, 1982 to December 31, 1984, or in the period from January 3, 1989 to December 30, 1991. The stock price information for our study is drawn from the Daily Return File from the Center for Research in Security Prices (CRSP).

Table II

The Distribution of Target Firms

	1982-1984		1989-1991	
Industry	Negotiated	Bidding	Negotiated	Bidding
Banking and Finance	2	1	6	2
Food and Beverage	4	0	2	0
Investment	16	6	16	2
Insurance	4	0	0	2
Oil and Gas	4	4	3	1
Retail	3	6	4	2
Total	33	17	31	9

Table II reports the distribution of target firms in our sample. In the period of lax regulations (1982-1984), there are 50 takeover targets that satisfy our sample selection criteria.

Among them 33 takeover events are identified as negotiated takeovers and 17 as takeovers initiated by bidding. In the period of tight regulation (1989-1991), there are 40 takeover targets that satisfy our sample selection criteria. Among them 31 takeover events are identified as negotiated takeovers and 9 as takeovers initiated by bidding.

4.3 Estimating Price Movements and Price Changes

Recall that in Chapter 3, we developed a segmented diffusion model to capture the capitalization process during a corporate takeover in terms of cumulative abnormal returns. The segmented diffusion model is a system of simultaneous equations:

$$\Delta CAR_t = \begin{cases} \alpha CAR_t + \varepsilon_{1t}, & t = -T,\ldots,-1 \\ \beta(\hat{CAR}^* - CAR_t) + \varepsilon_{1t}, & t = 1,\ldots,T \end{cases}$$
$$CAR_t = \begin{cases} \mu_0 \hat{CAR}^* e^{\alpha t} + \varepsilon_{2t}, & t = -T,\ldots,-1 \\ \hat{CAR}^* - (1 - \mu_1)\hat{CAR}^* e^{-\beta t} + \varepsilon_{2t}, & t = 1,\ldots,T \end{cases} \tag{49}$$

where date 0 is the last day before the announcement; CAR_t is the cumulative abnormal rerun up to date t; $\hat{CAR}^*$ is the expected total cumulative abnormal return from -T to T; μ_0 is the price run-up prior to the announcement; μ_1 is the price run-up up to date 1; α is the rate of price run-up prior to the announcement; β is the rate of price run-up after the announcement; and $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are given by

$$\varepsilon_{1t} = \begin{cases} \sigma(W_{t+1} - W_t), & t = -T,\ldots,-1 \\ \sigma(W_t - W_{t-1}), & t = 1,\ldots,T \end{cases}$$
$$\varepsilon_{2t} = \begin{cases} \sigma\int_0^t e^{\alpha(t-s)} dW_s, & t = -T,\ldots,-1 \\ \sigma\int_0^t e^{-\beta(t-s)} dW_s, & t = 1,\ldots,T \end{cases} \tag{50}$$

The estimation of the system of simultaneous equations (49) can be carried out by constrained optimization that maximizes the concentrated log likelihood function

$$L(\alpha,\beta,\hat{CAR}^{*},\mu_0,\mu_1) = -\frac{1}{2}\log|\Omega| - 2T\log(\eta'\Omega^{-1}\eta) \tag{51}$$

subject to

$$\varepsilon_{2,0} = 0 \tag{52}$$

4.3.1 Shifts of regulatory regimes

We now investigate the change in model parameters in response to the change of insider trading regulations. Previously, we identified two distinct regulatory regimes. The first period between 1982-1984 was one of relatively lax regulation and enforcement, and is denoted by subscript 1. The second period between 1989-1991 was one of tight regulation and enforcement, and is denoted by subscript 2. We now construct a system of equations that combines two segmented diffusion processes together. Recall from Chapter 3 (section 3.4.2) that this system combining two segmented diffusion models consists of four simultaneous equations which can be written as:

$$\Delta CAR_{1t} = \begin{cases} \alpha_1 CAR_{1t} + \varepsilon_{1t} \,, & t = -T,\ldots,-1 \\ \beta_1 (\hat{CAR}_1^* - CAR_{1t}) + \varepsilon_{1t} \,, & t = 1,\ldots,T \end{cases}$$
$$CAR_{1t} = \begin{cases} \mu_{01} \hat{CAR}_1^* e^{\alpha_1 t} + \varepsilon_{2t} \,, & t = -T,\ldots,-1 \\ \hat{CAR}_1^* - (1 - \mu_{11}) \hat{CAR}_1^* e^{-\beta_1 t} + \varepsilon_{2t} \,, & t = 1,\ldots,T \end{cases}$$
$$\Delta CAR_{2t} = \begin{cases} \alpha_2 CAR_{2t} + \varepsilon_{3t} \,, & t = -T,\ldots,-1 \\ \beta_2 (\hat{CAR}_2^* - CAR_{2t}) + \varepsilon_{3t} \,, & t = 1,\ldots,T \end{cases} \qquad (53)$$
$$CAR_{2t} = \begin{cases} \mu_{02} \hat{CAR}_2^* e^{\alpha_2 t} + \varepsilon_{4t} \,, & t = -T,\ldots,-1 \\ \hat{CAR}_2^* - (1 - \mu_{12}) \hat{CAR}_2^* e^{-\beta_2 t} + \varepsilon_{4t} \,, & t = 1,\ldots,T \end{cases}$$

where $\varepsilon_{1,t}$, $\varepsilon_{2,t}$, $\varepsilon_{3,t}$ and $\varepsilon_{4,t}$ are defined accordingly

$$\varepsilon_{1t} = \begin{cases} \sigma_1 (W_{t+1} - W_t) \,, & t = -T,\ldots,-1 \\ \sigma_1 (W_t - W_{t-1}) \,, & t = 1,\ldots,T \end{cases}$$
$$\varepsilon_{2t} = \begin{cases} \sigma_1 \int_0^t e^{\alpha_1 (t-s)} dW_s \,, & t = -T,\ldots,-1 \\ \sigma_1 \int_0^t e^{-\beta_1 (t-s)} dW_s \,, & t = 1,\ldots,T \end{cases}$$
$$\varepsilon_{3t} = \begin{cases} \sigma_2 (W_{t+1} - W_t) \,, & t = -T,\ldots,-1 \\ \sigma_2 (W_t - W_{t-1}) \,, & t = 1,\ldots,T \end{cases} \qquad (54)$$
$$\varepsilon_{4t} = \begin{cases} \sigma_2 \int_0^t e^{\alpha_2 (t-s)} dW_s \,, & t = -T,\ldots,-1 \\ \sigma_2 \int_0^t e^{-\beta_2 (t-s)} dW_s \,, & t = 1,\ldots,T \end{cases}$$

We also define the change in the model parameters by:

$$\begin{aligned} \Delta\alpha &= \alpha_2 - \alpha_1 \\ \Delta\beta &= \beta_2 - \beta_1 \\ \Delta\mu_0 &= \mu_{02} - \mu_{01} \\ \Delta\mu_1 &= \mu_{12} - \mu_{11} \\ \Delta\hat{CAR}^* &= \hat{CAR}_2^* - \hat{CAR}_1^* \end{aligned} \tag{55}$$

We refer to this system combing two segmented diffusion models as a nested system of segmented diffusion model.

To examine the changes in the model parameters, we construct two time series of average cumulative abnormal returns, one for the period of lax regulations and another for the period of tight regulations. Then we estimate the nested system by using the first time series for equations denoted by subscript 1 and by using the second time series for equations denoted by subscript 2. Since the two time series are separated by roughly four years, we assume that they are serially independent. Under this assumption, the concentrated log likelihood function of the nested system of segmented diffusion model is simply the sum of two concentrated log likelihood functions of the original non-nested segmented diffusion model: one for the period of lax regulations and another for the period of tight regulations. If L^* denotes the concentrated log likelihood function of the nested system, then we estimate the nested system of two segmented diffusion model (53) by using constrained optimization that maximizes

$$\begin{aligned} &L^*(\alpha_1,\beta_1,\mu_{01},\mu_{11},\hat{CAR}_1^*,\Delta\alpha,\Delta\beta,\Delta\mu_0,\Delta\mu_1,\Delta\hat{CAR}^*) \\ &= L(\alpha_1,\beta_1,\mu_{01},\mu_{11},\hat{CAR}_1^*) + L(\alpha_1+\Delta\alpha,\beta_1+\Delta\beta,\mu_0+\Delta\mu_0,\mu_1+\Delta\mu_1,\hat{CAR}_1^*+\Delta\hat{CAR}^*) \end{aligned} \tag{56}$$

L^* subject to two defining constrains

$$\begin{aligned} \varepsilon_{2,0} &= 0 \\ \varepsilon_{4,0} &= 0 \end{aligned} \tag{57}$$

where L is given by equation (51).

The estimates of parameters $\Delta\alpha$, $\Delta\beta$, $\Delta\mu_0$, $\Delta\mu_1$ and $\Delta\hat{CAR}^*$ provides us with estimated changes between the two regulatory regimes. This allows us to make inferences about the effects of regulatory changes on price movements.

4.3.2 Measuring abnormal returns

Abnormal returns of an event are defined conceptually as excess returns conditional on that the event occurs over returns conditional on that the event does not occur. As the returns conditional on no event occurring are not observable ex-post, in practice, we proxy the unobservable returns by various methods. There are several ways to proxy the abnormal returns. One of the most popular ways is estimate the abnormal returns based on the CAPM. However, the application of the CAPM involves two kinds of problems. First, the application of the CAPM requires us to observe the return to the market portfolio, which in practice is impossible to obtain exactly.[57] Therefore, various proxies for the market return are introduced. The use of a proxy for the market return introduces the problem of errors-in-variables into the application of residual analysis. A number of attempts have been made to deal with this problem, but resolution is still incomplete.[58] Secondly, recent empirical studies on market anomalies have challenged the CAPM as an equilibrium specification of the return generation process.[59] Although the procedure used to test the CAPM is

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[57] For a discussion on this issue, see, for example, Roll (1977).

[58] For instance, Blume (1970) first suggests that the errors-in-variables problem can be partially dealt with by constructing portfolios of the same risk class so that errors are off-set each other within a portfolio. Fama and MacBeth (1973) develop an estimation procedure that can further reduce the estimation bias due to the proxy for the market return.

[59] Among all kinds of market anomalies, earnings variables, size, and seasonal anomalies are perhaps the most noted. Earlier evidence on earnings anomalies can be fund in Jones and Litzenberger (1970), Litzenberger, Joy and Jones (1971), Basu (1977) and others. Ball (1978) argues that systematic experimental error can not explain all the anomalies reported in those studies and concludes that the evidence is possibly due to the failure of the CAPM. Subsequent evidence on earnings anomalies seems to affirm the earlier

still subject to dispute, the evidence seems to be strong enough to consider seriously an alternative approach of measuring abnormal returns that does not depend on the CAPM.

Table III

Number of Firms Included in Each Industry Portfolio

	1982-1984	1989-1991
Banking & Finance	59	77
Food & Beverage	30	22
Investment	93	101
Insurance	30	31
Oil & Gas	95	77
Retail	63	52

For the reasons mentioned above, we measure the abnormal returns of a target firm by the

findings (See, for example, a recent survey by Ball (1992)). The size effect is first noticed by Banz (1981) and Reinganum (1981). Reinganum (1981) argues that the CAPM might have mis-specified the equilibrium return process. Roll (1981, 1983), Blume and Stambaugh (1983) and Stoll and Whaley (1983) explain that part of the small firm effect may due to non-synchronous trading, or portfolio strategies, or transaction costs. However, Reinganum (1982), Roll (1983) and Schwert (1983) conclude that the bias in estimation cannot fully explain the anomalous size effect. Earlier evidence on seasonal anomalies is documented by Officer (1975) and Rozeff and Kinney (1976) for January effect and by French (1980) and Gibbons and Hess (1981) for weekend effect. Later evidence shows that earnings, size and seasonal anomalies may related to each other. For example, Brown, Kleidon and Marsh (1983), Keim (1983) and Reinganum (1983) find that size and January effects are related, Basu (1983) and Cook and Rozeff (1984) find that earnings and size effects are related. Penman (1987) and Damodaran (1989) find that earnings and weekend effects are related. Jaffe, Keim and Westerfield (1989) find that earnings, size and the January effects are related. There are some other empirical anomalies that are also received considerable attention. Bhandari (1988) reports that debt/equity ratio explains stock returns. Rosenberg, Reid and Lanstein (1985) and Chan, Hamao and Lakonishok (1991) report that book-to-market value explains stock returns. Chen, Roll and Ross (1986) and Fama and French (1993) report that term structure variables explain stock returns. Fama and French (1992, 1993) conclude that size, leverage, book-to-market value, price/earnings ratio and term structure variables are all related to each other and they can explain seasonal anomalies in stock returns. Due to the controversy of the empirical evidence on the CAPM, we appeal to the basic method that uses an equally weighted industry average as a benchmark for the computation of the abnormal return.

excess returns to the target over the returns to the industry average. The industry average is an equally weighted portfolio of firms within the industry excluding the takeover targets included in our sample. Firms included in an industry portfolio must have a SIC code within the range specified for the industry in section 4.2.1, and must be continuously listed for trading from January 4, 1982 to December 31, 1984, or from January 3, 1989 to December 30, 1991. In the construction of the industry average returns, missing data are treated as no observation, that is, when a firm has a missing observation for a particular date, the industry average return for that date is the average return of the firms in the industry that have data for that date. Table III reports the number of firms used to calculate average returns for each industry over two separated sampling periods.

4.3.3 Announcement dates

It is customary in event studies to consider the date when the WSJ reports the takeover as the announcement date.[60] The WSJ, however, often reports takeovers one or a few days after the actual announcement of the takeovers has been made. In addition to this, a takeover attempt could sometimes become known to the public several days before the official announcement about the takeover is actually made. For example, firms involved in the negotiation of a takeover deal sometimes acknowledge the merger talks in press releases prior to the merger announcement. As we use pre-announcement price run-ups as an indirect measure of illegal insider trading, it is crucial to distinguish the price run-up induced by illegal insider trading from the price run-up caused by news announcements, such as, acknowledgement of merger talks. Consequently, we specify any of

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[60] Earlier event studies of takeovers use the date of final approval by target shareholders as the event date (See, for example, Mandelker (1974) and Ellert (1976)). Dodd and Ruback (1977) propose to use the date when the tender offer is first published in the Wall Street Journal as the event date. The Dodd-Ruback method provides a better estimation of the price effect of the takeover event. Recently, Jarrell and Poulsen (1989) introduce adjustment to the Newspaper announcement date to correct the news delay for true announcement date. We follow Jarrell-Poulsen approach here.

the following announcements, which ever is the earliest, as the "takeover announcement": (1) an announcement that discloses a definite or preliminary merger agreement between the acquirer and the acquiree; (2) an announcement, usually made by the bidder, that claims a tender offer bid has been made; (3) an announcement that acknowledges merger talks by any party involved in the talk; and (4) an announcement that disclosures a proposal of acquisition by either party involved in the deal. News reports made by parties not involved in the deal of takeover that indicate the likelihood of an impending takeover are not considered as takeover announcements but as rumours.

Table IV

Number of days Adjusted to Correct for the Delay in Newspaper Reporting

	1982-1984	1989-1991
Number of Days Adjusted	Number of Firms	Number of Firms
0	1	0
-1	23	15
-2	26	24
-3	0	1
Mean Adjustment (days)	1.50	1.65

One problem of using news reports to identify the announcement date is that it is sometimes difficult to determine from reports exactly when the first announcement is made. Therefore we examine reports from several sources and use cross checking to identify the correct "takeover announcement" date. Sources used for the cross checking are WSJ, NYT and MR. When different sources report the announcement on different days, the earliest announcement is chosen. Another problem with the reports is the time delay in reporting the actual announcement. To deal with the delay in reporting, we checked through the original news reports on takeover announcement in the WSJ and the NYT to identify as accurate as possible the number of days delayed in newspaper reporting. According to the content of the news report, we have adjusted for most newspaper reports backwards by one to three days from the date when the announcement is reported to correct the delay in reporting. Table IV summarizes the adjustment of the announcement date for all target firms in the sample.

4.4 Empirical Results

Empirical results are obtained respectively from the estimation of two different systems of simultaneous equations. First, we estimate the system of equations (49), a single segmented diffusion model, using the procedure summarized in equation (51) and equation (52). Equation (49) is estimated in turn for each type of takeover (negotiated takeovers and takeovers initiated by bidding) in each regulatory regime (a period of lax regulations between 1982-1984 and a period of tight regulations between 1989-1991). Table V presents the results of the estimation for the two regulatory regimes and for two types of takeovers: negotiated takeovers ("negotiated") and takeovers initiated by bidding ("bidding"). Next, we estimate the system of equations (53), a nested system combining two segmented diffusion models, using the procedure summarized in equation (56) and equation (57). Equation (53) is estimated for each type of takeover. Table VI presents the results of the estimation.

Before proceeding to analyze empirical results, recall that in section 2.5 of Chapter 2 we developed three hypotheses to be tested. These hypotheses were all formulated in terms of parameters of the continuous time version of the segmented diffusion process. Here we need to respecify these hypotheses in terms of parameters of the discrete time version of the segmented diffusion model (equations (49) and equations (53)). That is, we need to find the correspondence for $\frac{d\mu^-}{dl}$ and $\frac{d\mu}{dl}$ appeared in the hypotheses formulated earlier. Recall that in the continuous time segmented diffusion process, μ^- is the price run-up prior to but not including the announcement time t_0 and μ is the price run-up prior to and including the announcement time t_0. In the discrete time version of the segmented diffusion model, date 0 is the last trading day before the announcement, μ_0 is the price run-up prior to the announcement, μ_1 is the price run-up up to date 1. We have specified earlier that $0 < t_0 < 1$.

Consider a sample of two sets of cumulative abnormal returns of takeover targets: one set from a regime of lax regulation and another set from a regime of tight regulation. Let $\Delta\mu_0$ be the change in the sample average price run-up prior to the announcement (up to date 0), from the regime of lax regulation to the regime of tight regulation. Similarly, let $\Delta\mu_1$ be the change in the sample average price run-up up to date 1, from the regime of lax regulation to the regime of tight regulation. Then $\Delta\mu_0$ and $\Delta\mu_1$ are the best sample characterizations of the average of $\frac{d\mu^-}{dl}$ and the average of $\frac{d\mu}{dl}$.

With $\Delta\mu_0$ and $\Delta\mu_1$ being the sample characterizations of the average of $\frac{d\mu^-}{dl}$ and $\frac{d\mu}{dl}$, we are now ready to analyze each hypothesis in turn.

Table V
Estimation of Segmented Diffusion Model During Lax and Tight Regulations

Estimated segmented diffusion model of average cumulative abnormal returns for lax and tight regulatory regimes and for the two types of takeovers. Model specification is given by the system of two equations presented below, with t=0 being the announcement date. The window for the time series starts at 15 days before the announcement date and ends 15 days after the announcement date. The number of firms ("No. Firms") reports the number of target firms for which the average cumulative abnormal returns are constructed. L is the value of the log likelihood function. Asymptotic t-values are in parentheses.

$$\Delta CAR_t = \begin{cases} \alpha CAR_t + \varepsilon_{1t} & t=-T,\ldots,-1; \\ \beta(\hat{CAR}^* - CAR_t) + \varepsilon_{1t} & t=1,\ldots,T; \end{cases}$$

$$CAR_t = \begin{cases} \mu_0 \hat{CAR}^* \exp(\alpha t) + \varepsilon_{2t} & t=-T,\ldots,-1; \\ \hat{CAR}^* - (1-\mu_1)\hat{CAR}^* \exp(-\beta(t-1)) + \varepsilon_{2t} & t=1,\ldots,T. \end{cases}$$

Parameter	1982-1984		1989-1991	
	Negotiated	Bidding	Negotiated	Bidding
α	.27224 (10.981)	.28422 (6.9077)	.17092 (3.9368)	.12300 (1.2601)
β	.26112 (2.1239)	.44567 (2.3473)	.97484 (5.9254)	.69358 (4.6409)
$\hat{CAR}^*$	.24397 (71.246)	.24657 (83.374)	.34148 (432.48)	.24148 (74.366)
μ_0	.44211 (23.130)	.42361 (15.242)	.13299 (13.419)	.21062 (5.3172)
μ_1	.99330 (55.970)	1.0273 (47.126)	.96014 (102.11)	.95000 (26.008)
L	219.72	195.07	229.03	163.71
No. Firms	33	17	31	9

Table VI
Estimation of Nested Segmented Diffusion Model for Both Lax and Tight Regulations

Estimated changes in Average cumulative abnormal returns for each type of takeover. The estimation is conducted by combining the two segmented diffusion models specified below, with t=0 being the announcement date. Window starts at 15 days before the announcement date and ends 15 days after the announcement date. Subscript 1 indicates the period of lax regulations between 1982-1984, and subscript 2 the period of tightly regulations between 1989-1991. The number of firms ("No. Firms") reports the total number of target firms in the pooled sample. L^* is the value of log likelihood function. Asymptotic t-values are in parentheses.

$$\Delta CAR_{1t} = \begin{cases} \alpha_1 CAR_{1t} + \varepsilon_{1t} & t=-T,\ldots,-1; \\ \beta_1(\hat{CAR}^*_1 - CAR_{1t}) + \varepsilon_{1t} & t=1,\ldots,T; \end{cases}$$

$$CAR_{1t} = \begin{cases} \mu_{01}\hat{CAR}^*_1 \exp(\alpha_1 t) + \varepsilon_{2t} & t=-T,\ldots,-1; \\ \hat{CAR}^*_1 - (1-\mu_{11})\hat{CAR}^*_1 \exp(\beta_1(t-1)) + \varepsilon_{2t} & t=1,\ldots,T; \end{cases}$$

$$\Delta CAR_{2t} = \begin{cases} (\alpha_1+\Delta\alpha)CAR_{2t} + \varepsilon_{3t} & t=-T,\ldots,-1; \\ (\beta_1+\Delta\beta)((\hat{CAR}^*_1+\Delta\hat{CAR}^*) - CAR_{2t}) + \varepsilon_{3t} & t=1,\ldots,T; \end{cases}$$

$$CAR_{2t} = \begin{cases} (\mu_{01}+\Delta\mu_0)(\hat{CAR}^*_1+\Delta\hat{CAR}^*)\exp((\alpha_1+\Delta\alpha)t) + \varepsilon_{4t} & t=-T,\ldots,-1; \\ (\hat{CAR}^*_1+\Delta\hat{CAR}^*) - (1-(\mu_{11}+\Delta\mu_1))(\hat{CAR}^*_1+\Delta\hat{CAR}^*)\exp((\beta_1+\Delta\beta)(t-1)) + \varepsilon_{4t} & t=1,\ldots,T; \end{cases}$$

Parameter	Negotiated	Bidding	Parameter	Negotiated	Bidding
α_1	.27408 (11.145)	.26440 (6.4547)	$\Delta\alpha$	-.10316 (-2.0677)	-.14482 (-1.3707)
β_1	.26112 (2.1419)	.43856 (2.3252)	$\Delta\beta$	.71372 (3.4892)	.26443 (1.0979)
$\hat{CAR}^*_1$	.24397 (71.497)	.24650 (82.423)	ΔCAR^*	.09751 (27.841)	-.00506 (-1.1538)
μ_{01}	.45994 (24.288)	.43264 (15.937)	$\Delta\mu_0$	-.32695 (-15.297)	-.22153 (-4.6252)
μ_{11}	.99329 (56.329)	1.0272 (47.058)	$\Delta\mu_1$	-.03315 (-1.6589)	-.07657 (-1.8018)
No. Firms	64	26	L^*	449.26	358.96

4.4.1 Information revelation and the effect of tightened regulations

Hypothesis I deals jointly with information revelation and the effectiveness of the regulatory change. It is hypothesized that the tightening of the regulations is effective and inside information is partially revealed to the market, that is, $\Delta\mu_0 < 0$ and $\Delta\mu_1 = 0$. In the segmented diffusion model, μ_0 is the average price run-up to the day before the announcement, and μ_1 is the average price run-up to and at the announcement date. Both run-ups are measured as a percentage of the average expected total cumulative abnormal returns over the entire event period. Table V reports that the estimated average price run-up to the day before the announcement is 44.2% for negotiated takeovers and 42.4% for takeovers initiated by bidding, for the period 1982-1984. In contrast, the estimated average price run-up to the day before the announcement is, for the period 1989-1991, 13.3% for negotiated takeovers and 21.1% for takeovers initiated by bidding. Clearly, the average price run-up before the announcement dropped dramatically over time for both types of takeovers. It dropped by 70% for negotiated takeovers, and by 50% for takeovers initiated by bidding. On the other hand, the average price run-up to and at the announcement date, μ_1 did not change much over time. Table V reports that μ_1 is 99.3% for negotiated takeovers and 102.7% for takeovers initiated by bidding, in the period 1982-1984; and is 96.0% for negotiated takeovers and 95.0% for takeovers initiated by bidding, in the period 1989-1991.

As we have controlled for other impacts that are likely to induce changes in price movements across regulatory regimes, we attribute the decline in the average price run-up μ_0 over time to the effectiveness of the regulatory changes. Table VI reports that the changes in the average price run-up before the announcement, $\Delta\mu_0$, is statistically significant for both types of takeovers. The asymptotic t value for $\Delta\mu_0$ is -15.3 for negotiated takeovers and -4.6 for takeovers initiated by bidding. In contrast, the changes in the average price run-up to and at the announcement date, $\Delta\mu_1$, are not significant at the .05 level for a two-sided test. The evidence strongly supports hypothesis I that the tightening of regulations is effective, and that the inside information is partially revealed to the market. The evidence is inconsistent with either the full revelation theory or the non-revelation theory.

One concern regarding this dramatic change in the average price run-up, μ_0, is whether the result is due to incorrect choice of the announcements dates in estimation. As indicated earlier, we have adjusted backwards for most takeovers the announcement dates from the newspaper reporting dates. The adjustment is to correct the delay in newspaper reporting of the actual takeover announcement. If the announcement dates were over-adjusted for the targets in the period between 1989-1991, then the over adjustment would reduce the level of price run-up prior to the announcement. Table IV reports that the mean adjustment for the period between 1982-1984 is 1.5 days and for the period between 1989-1991 is 1.65 days. On average, the adjustment is slightly bigger for the second period. There are at least two ways of checking whether our adjustment is reliable. The first one is to compare our results with those of similar studies. Two recent empirical studies used a similar method to identify the correct announcement date. Jarrell and Poulsen (1989) studied tender offers between 1981-1985. They adjusted the WSJ reporting date of the announcement based on the news releases from the Dow Jones News Service, which is considered as a more accurate source for takeover announcements. They found that the average price run-up before the announcement was 44.2%. Meulbroek (1992) studied takeovers involving illegal insider trading between 1974-1988. She used both the Dow Jones News Service and the Dow Jones Headline Tapes to identify the correct announcement dates. She found that the average pre-announcement price run-up was 42.5%.

Our first period (1982-1984) lies in the range of the periods studied by these two studies, and our findings are similar to theirs (44.2% for negotiated takeovers and 42.4% for takeovers initiated by bidding). With regard to whether the announcement dates in our study for the second period were over-adjusted, we examined also the average price run-up to and at the announcement date, μ_1. If the announcement dates were over-adjusted backwards for the second period, then the price run-up to and at the announcement date, μ_1, would be smaller for the second period. As pointed out earlier, Table V indicates that μ_1 did not change much over time, and Table VI shows that the changes in μ_1 are insignificant. In contrast with changes in μ_0, changes in μ_1 are negligible. The overall evidence suggests that the dramatic changes in μ_0 are not likely a result of experimental error.

There are two parameters in the segmented diffusion model that characterize the price movements prior to the announcement. In addition to μ_0, parameter α describes the rate of price run-up before the announcement, which reflects the efficiency of the market incorporating inside information into stock prices. Under partial revelation of information, a larger value of α represents a greater ability of the market to incorporate inside information. If the market's ability to digest information remained unchanged over time, then the change in α across regulatory regimes would reflect the change in the amount of information that flowed into the market. Table V shows that α dropped over time for both types of takeovers. For negotiated takeovers, it dropped by 36% from .27 to .17. For takeovers initiated by bidding, it dropped by 57 % from .28 to .12. Table VI reports that the change in α, $\Delta\alpha$, is statistically significant for negotiated takeovers at the .01 level. However, $\Delta\alpha$ for takeovers initiated by bidding is not statistically significant. We will discuss later, this difference between negotiated takeovers and takeovers initiated by bidding.

If regulations on insider trading partially inhibit insiders from trading before announcement, then tightening of the regulations would delay further the amount of information flowing into the market prior to the announcement time. Since all the information regarding the impending takeover are known after the announcement, a drop in α would imply an increase in β. Table V shows that the rate of the estimated average price run-up after the announcement, β, increased from .26 in the period 1982-1984 to .97 in the period 1989-1991 for negotiated takeovers and increased from .45 in the period 1982-1984 to .69 in the period 1989-1991 for takeovers initiated by bidding. Table VI shows that the change in the average price run-up after the announcement, $\Delta\beta$, is statistically significant for negotiated takeovers but is not significant for takeovers initiated by bidding.

Previous research indicates that several factors are likely to cause price run-up prior to the announcement. These include illegal insider trading, press speculation, unidentifiable rumours, purchases by bidders before takeover to increase the chance of takeover success, and mis-identification of the exact announcement date. The problem of mis-identification of the exact announcement dates was corrected in recent studies. There remains, however, a strong disagreement about the reasons for pre-announcement price run-ups. For example, Jarrell and Poulsen (1989) concluded that press speculation explained most of the pre-announcement price run-up in their study, whereas illegal insider trading explained very little of the pre-announcement price run-up. Although they suspect that undetected illegal insider trading in their sample may have affected their results, they speculated that illegal insider trading is not a major source of the pre-announcement price run-up. In contrast, Meulbroek (1992) reported that 43.2% of the pre-announcement price run-up in her study was caused by illegal insider trading. We have used a quasi-experimental design that should have filtered out other effects on price run-ups except illegal insider trading and found that a large portion of the pre-announcement price run-up are due to illegal insider trading, at least in the early 1980's.

4.4.2 Comparison between negotiated takeovers and takeovers initiated by bidding

Hypothesis II deals with the difference between negotiated takeovers and takeovers initiated by bidding. The hypothesis maintains that the impact of regulatory change is greater in the case of negotiated takeovers than in the case of takeovers initiated by bidding, that is, $|\Delta\mu_0^N| > |\Delta\mu_0^B|$.

The issue whether the change of regulations impacts more negotiated takeovers is analyzed by comparing the changes in pre-announcement price run-ups, $\Delta\mu_0$, between the two types of takeovers. Table V shows that, in response to the regulatory changes, the pre-announcement price movements changed more for negotiated takeovers than for takeovers initiated by bidding. Before the regulatory changes, the pre-announcement price run-up parameters are similar for the two types of takeovers: the average price run-up before the announcement μ_0 is 44.2% vs. 42.4%. After the regulatory changes, however, the average price run-up before the announcement μ_0 is quite different, viz: 13.3% vs. 21.1%. The comparison across regulatory regimes for each type of takeover drawn from Table V also shows that, as already mentioned earlier, the average price run-up to the announcement date dropped more for negotiated takeovers than for takeovers initiated by bidding. Table VI shows that the change in pre-announcement price run-up for negotiated takeovers, $\Delta\mu_0^N$, is -32.7%, and the change in pre-announcement price run-up for takeovers initiated by bidding, $\Delta\mu_0^B$, is -22.2%. Both changes are statistically significant. The result in Tables V and VI are consistent and they both imply that $|\Delta\mu_0^N| > |\Delta\mu_0^B|$. The evidence supports Hypothesis II.

The evidence reveals that, before the regulatory changes, the level of price run-up μ_0 is higher for negotiated takeovers than for takeovers initiated by bidding. After the regulatory changes, the level of price run-up μ_0 is lower for negotiated takeovers than for takeovers initiated by bidding. This evidence is consistent with the conjecture stated earlier that insiders in takeovers initiated by bidding are able to substitute legal trades for illegal trades so that the tightening of regulations did not reduce insider trading during takeovers initiated by bidding as much as it did to negotiated takeovers.

A further examination of the parameter of the rate of pre-announcement price run-up, α, reveals more evidence concerning the differences between negotiated takeovers and takeovers initiated by bidding. As reported in Table V, before the regulatory changes, the rate of pre-announcement price run-up α is .27 vs. .28 for the two types takeovers. After the regulatory changes, the rate of pre-announcement price run-up is .17 vs. .12 for the two types of takeovers. The rates dropped for both types of takeovers. However, Table VI shows that the change in α for negotiated takeovers is significant but for takeover initiated by bidding is not significant. In addition to this, the rate of post-announcement price run-up, β, changed accordingly. Table VI shows that the change in β for negotiated takeovers is also significant but for takeovers initiated by bidding is not significant. In conjunction with Hypothesis I, this evidence suggests that tightened regulations have more effects on the amount of information flow into the market in the situation involving negotiated takeovers. Furthermore, after the regulatory changes, the pre-announcement price run-up for takeovers initiated by bidding started earlier and increased at a lower rate relative to negotiated takeovers (See figures 1 to 4). This observation agrees with our conjecture that, in the case of takeovers initiated by bidding, tightened regulations force insiders to substitute illegal trades with legal trades which take place earlier than if no regulatory changes occur.

4.4.3 Insiders' compensation associated with takeovers

Hypothesis III deals with whether the change in regulations leads to fewer but more profitable takeovers. As we discussed earlier, this hypothesis has important implications on the issue of insiders' compensation associated with takeovers. Hypothesis III maintains that the increase of the expected total cumulative abnormal return of negotiated takeovers is greater than the increase of the expected total cumulative abnormal return of takeovers initiated by bidding, i.e., $\Delta C\hat{A}R^{*N} > \Delta C\hat{A}R^{*B} \geq 0$.

We examined whether the changes in regulations led to fewer but more profitable takeovers by investigating the changes in the expected total cumulative abnormal return $C\hat{A}R^{*}$ over time. As indicated in Chapter 2, $\Delta C\hat{A}R^{*}$ reflects the increase in the expected gain from the takeover of the target between the two regulatory regimes of the different periods. Table VI shows that for negotiated takeovers, $C\hat{A}R^{*N}$ increased over the two periods by 42% from .24 to .34. Table VI shows that this change is statistically significant. For takeovers initiated by bidding, however, there was no significant change, although $C\hat{A}R^{*B}$ decreased a little over the two periods. The evidence is, in general, consistent with hypothesis III.

The comparison between this result and the result obtained earlier concerning the differences between the two types of takeovers raises some questions. On one hand, if insider trading during negotiated takeovers were indeed affected more by the changes in regulations, then average expected total cumulative abnormal returns of negotiated takeovers would increase more. In this respect, our results in testing Hypotheses II and III are consistent. On the other hand, our results in testing Hypothesis II indicates that the regulatory effects on both types of takeovers are significant. We would expect then that $\Delta C\hat{A}R^*$ for both types of takeovers would be positive and significant. However, our results regarding Hypothesis III suggest that the regulatory changes have almost no effect on takeovers initiated by bidding. In this respect, the results appear to be inconsistent.

We argue here that this seemingly inconsistency in evidence can be explained in part by the opportunity that insiders have in the case of takeovers initiated by bidding to make early legal trades to replace illegal trades. As we suggested earlier, if the takeover is started with an open bid for the target, the bidder can coordinate the timing between pre-takeover trades and the takeover announcements. In some circumstances, this coordination enables the bidder to cumulate sufficient amount of target shares *legally* before declaring the takeover. In contrast, it is more difficult to coordinate the two actions during negotiated takeovers, because the bidder in negotiated takeovers has less power to determine the outcome of the takeover. If this is indeed the case, then an effective change in regulation would reduce insider trading without leading the bidder to seek more profitable takeovers. That is, $\Delta\mu_0^N < 0$ and $\Delta C\hat{A}R^{*N} = 0$.

4.4.4 Justification of model specification

Below we provide the results of our investigations as to the validity of our specification using the segmented diffusion model. Table VII reports the serial correlations of the residuals for each regulatory regime and for each type of takeover.

The evidence indicates that, except for takeovers initiated by bidding in the period between 1989-1991, the serial correlations among the residuals for the discrete approximation of the differential equation (the first equation in the system of equation (49)) are negligible. However, the serial correlations among residuals for the solution to the differential equation are much larger. The evidence is consistent with the error term specification of the segmented diffusion model defined by equation (54).

Table VII

Serial Correlations among Residuals

$$\text{Serial correlation coefficient} = \frac{\sum_{t=-T}^{-2} \varepsilon_{i,t+1}\varepsilon_{i,t} + \sum_{t=1}^{T-1} \varepsilon_{i,t+1}\varepsilon_{i,t}}{\sum_{t=-T}^{T} \varepsilon_{i,t}} \quad , \ i = 1, 2$$

Where 1 is for the discrete approximation of the differential equation (difference equation) and 2 for the discrete version of the solution to the differential equation (solution).

	1982-1984		1989-1991	
	Negotiated	Bidding	Negotiated	Bidding
Difference Equation	.14358	.09250	-.04205	-.26321
Solution	.85077	.74346	.35471	.41416

Figure 1 to figure 4 compare the estimated model with the data. In each figure, we plot the estimated deterministic trend of the segmented diffusion model against actual average CARs. The overall fit supports our model specification presented in Chapter 2.

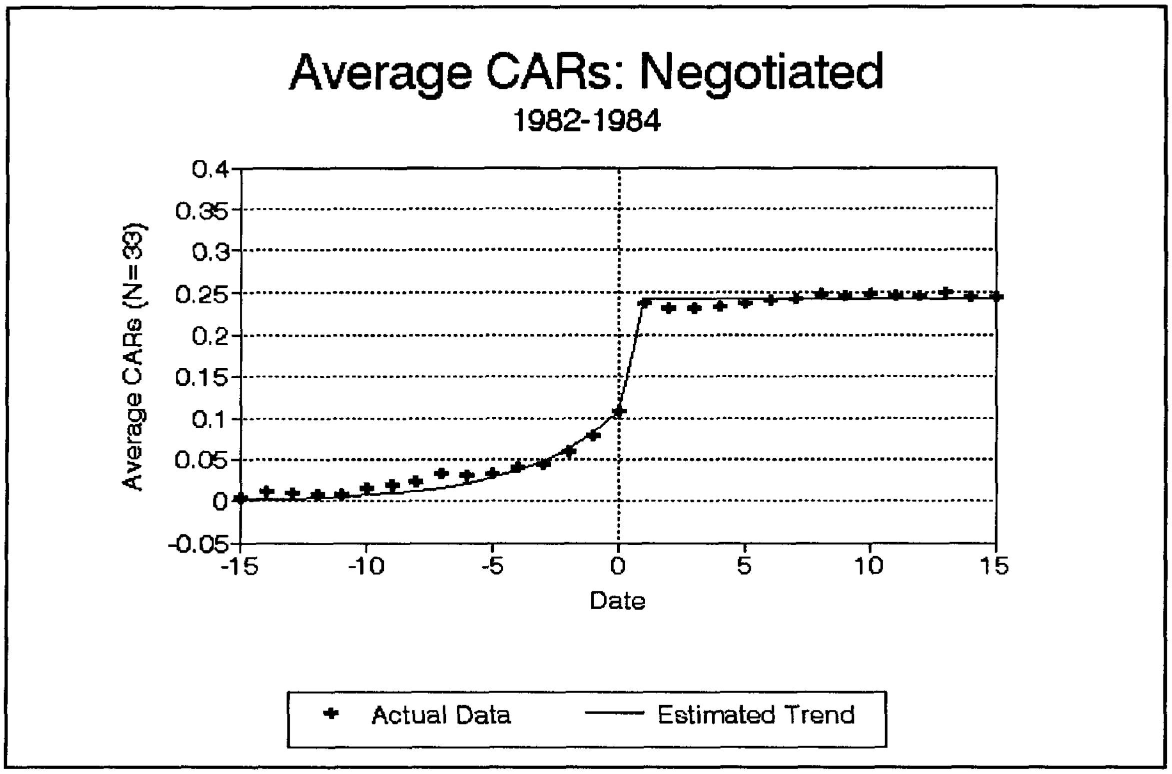

Figure 1

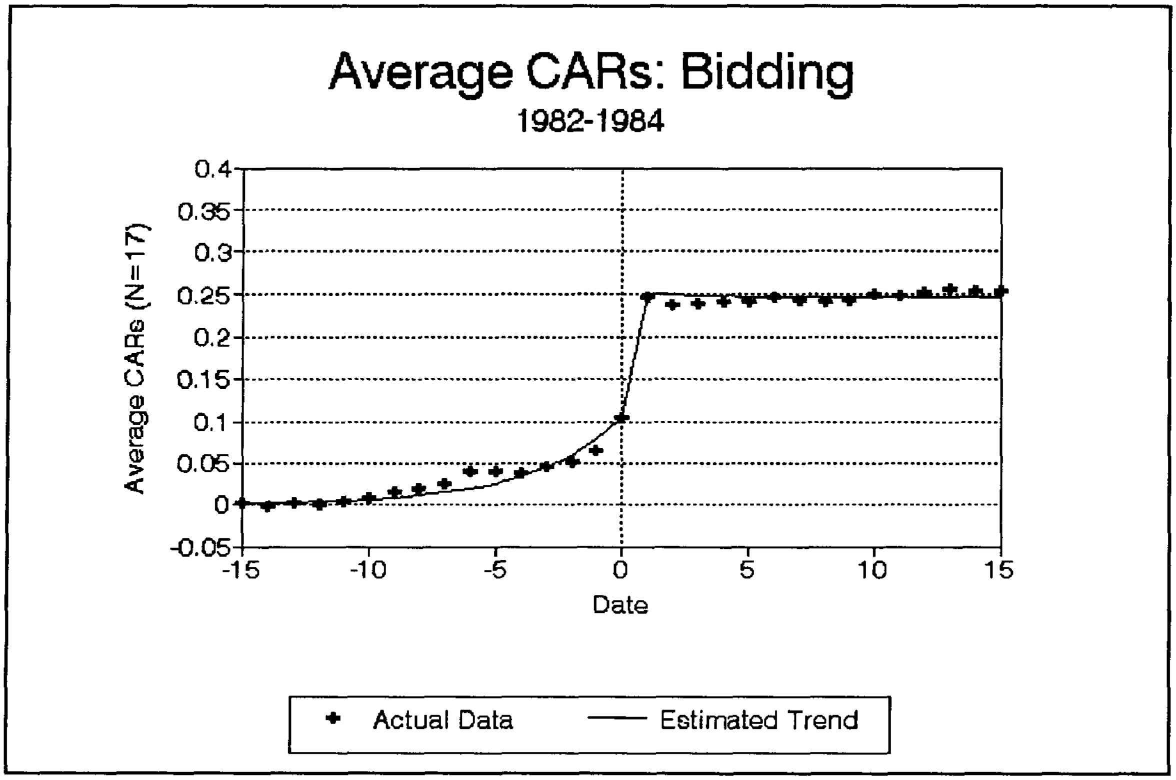

Figure 2

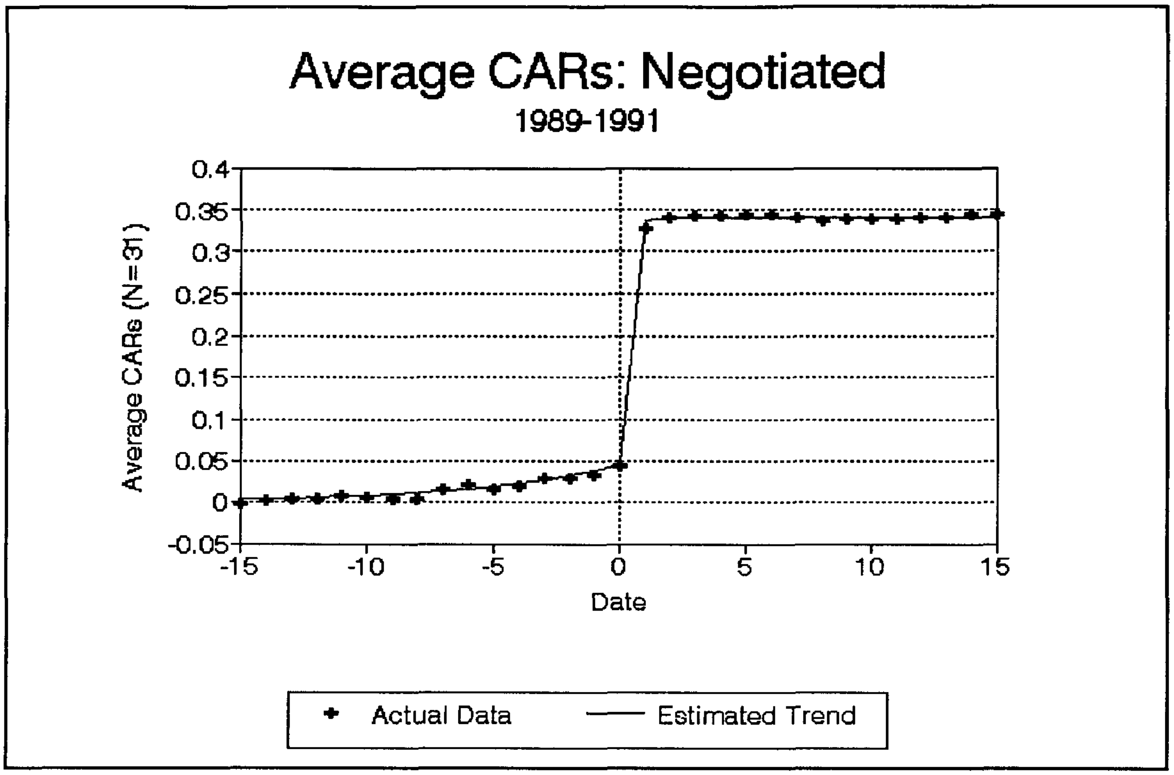

Figure 3

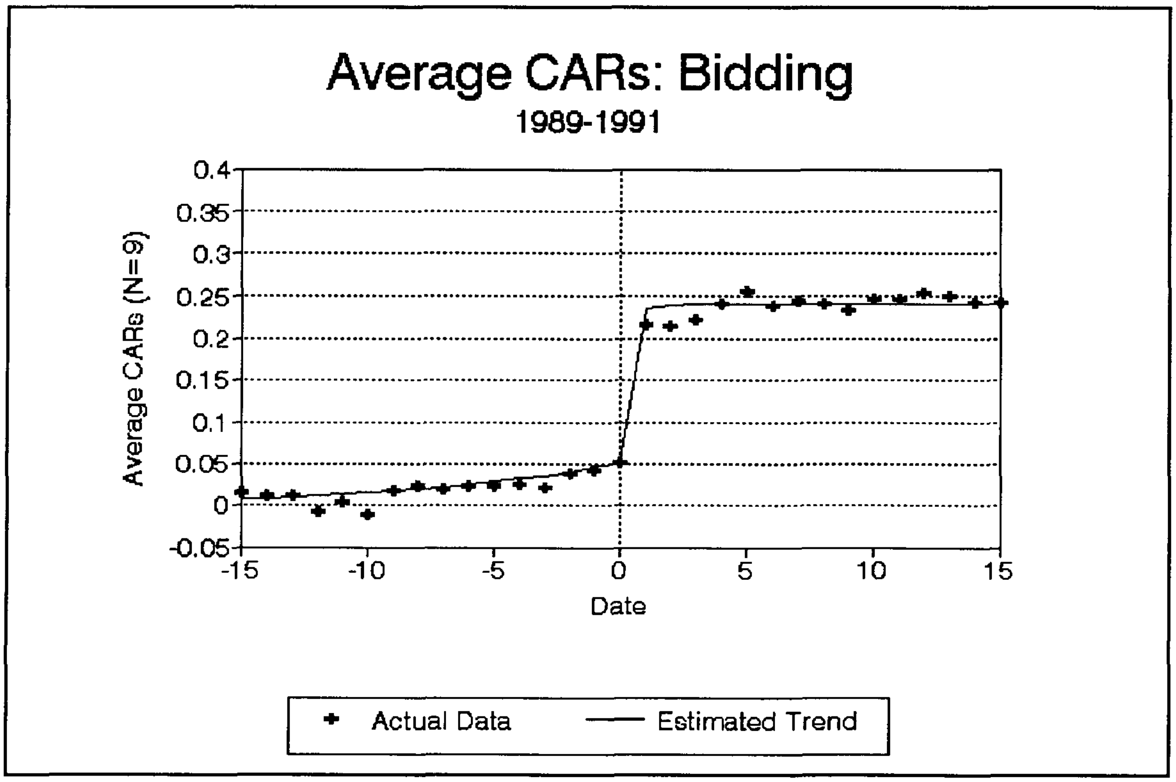

Figure 4

Table VIII
Estimation of Segmented Diffusion Process During Lax and Tight Regulations

Estimated segmented diffusion process of average cumulative abnormal returns for lax and tight regulatory regimes and for the two types of takeovers. Model specification is given by a single equation presented below, with t=0 being the announcement date. The window for the time series starts at 15 days before the announcement date and ends 15 days after the announcement date. The number of firms ("No. Firms") reports the number of target firms for which the average cumulative abnormal returns are constructed. L is the value of the log likelihood function. Asymptotic t-values are in parentheses. This estimation fails for takeovers initiated by bidding in the period between 1982-1984 due to the identification problem.

$$CAR_t = \begin{cases} \mu_0 \hat{CAR}^* \exp(\alpha t) + \varepsilon_t & t=-T,\ldots,-1; \\ \hat{CAR}^* - (1-\mu_1)\hat{CAR}^* \exp(-\beta(t-1)) + \varepsilon_t & t=1,\ldots,T. \end{cases}$$

Parameter	1982-1984		1989-1991	
	Negotiated	Bidding	Negotiated	Bidding
α	.25792 (10.032)		.21956 (4.5153)	.25674 (2.7122)
β	.12757 (1.0911)		1.6929 (2.0231)	.52516 (2.2678)
$\hat{CAR}^*$	.24668 (34.342)		.34166 (432.26)	.24335 (54.170)
μ_0	.43725 (18.456)		.12949 (10.875)	.20900 (5.3631)
μ_1	.95785 (32.394)		.96080 (136.29)	.88559 (28.505)
L	238.58		242.04	179.99
No. Firms	33		31	9

In addition, we also conducted estimation based on only the solution to the differential equation of the segmented diffusion process, which is the exact form of the process without approximation. Table VIII reports the result from the estimation. We are able to obtain estimation results for the exact model for all takeovers except takeovers initiated by bidding during the period between 1982-1984. The comparison between Tables V and VIII suggests that, except for parameters α and β, the estimates for the rest of the parameters are similar. Thus, the approximation introduced to our method seems reasonable.

4.5 Conclusion

The main results from our empirical study can be summarized as follows. First, the increased regulation of insider trading in the 1980s has been shown to be effective in reducing illegal insider trading. This is in contrast to previous studies that showed no effect of regulatory changes on insider trading. One possible explanation to the difference is perhaps due to the choice of the sample. The sample used in the earlier studies employed reported insider trading transactions (most of which are legal) which are rather insensitive to the regulatory changes. Our research design in this study focuses on illegal insider trading which are the target of the regulations.

Second, we found substantial evidence that insider trading regulations have different impacts on illegal insider trading associated with negotiated takeovers than on insider trading associated with takeovers initiated by bidding. This evidence seems to suggest that current regulation of insider trading permits to certain extent the substitution of early legal trades for later illegal trades, especially in the case of tender offers initiated by bidding.

Third, we also found weak evidence that tightening regulations may induce insiders to require higher profits from a takeover to compensate for the reduction in the opportunities to make profits by insider trading. As insider trading regulations become tighter, the less profitable takeovers may be deterred. However, our evidence on this may also be explained by other factors such as small sample bias.

Fourth, as has been reported by other studies, we found that insider trading reveals inside information to the market. Specifically, we conclude that inside information is only partially revealed to the market.

Finally, we checked the dynamic specification of using the segmented diffusion model. We found that overall evidence supports our model specification.

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4.7 Appendix: Information about Takeover Targets

4.7.1 Target Firms for the Period of 1982-1984

TARGET FIRM	SIC	EXCHANGE	ANNOUNCEMENT DATE WSJ/NYT/MR	ADJUSTED	ADJUSTMENT	TRANSACTION ($MILLIONS)	TYPE
A R A SERVICES INC	5962	NY	840913	840911	-2	873.2	BID
ADAMS DRUG INC	5912	NY	841003	841001	-2	100.0	NEG
ASSOCIATED COCA COLA BOTTLING	2086	NA	820511	820507	-2	417.5	NEG
BANCOHIO CORP	6711	NA	840123	840120	-1	297.0	BID
BROOKS FASHION STORES INC	5621	NY	840807	840803	-2	364.6	BID
CAMPBELL TAGGART INC	2051	NY	820804	820802	-2	570.2	NEG
CARNATION COMPANY	2013	NY	840905	840831	-2	2885.4	NEG
CENTRAL PENN NATL CORP	6711	NA	820917	820916	-1	159.4	NEG
CENTRAN CORP	6711	NA	840925	840921	-2	140.1	NEG
CHARTERCORP	6711	NA	840709	840706	-1	252.8	NEG
COLE NATIONAL CORP	5999	NY	840605	840601	-2	311.3	BID
COMMERCIAL ALLIANCE CORP	6711	AM	840628	840627	-1	184.3	NEG
CROCKER NATIONAL CORP	6025	NY	840716	840712	-2	263.9	BID
CULLEN FROST BANKERS INC	6711	NA	830727	830725	-2	287.6	NEG
EL PASO CO	4922	NY	830826	830824	-2	675.6	BID
ELLIS BANKING CORP	6711	NA	830817	830816	-1	168.3	NEG
EXCHANGE BANCORPORATION TAMPA	6711	NA	820601	820528	-1	134.0	BID
FEDERATED INVESTORS INC	6711	NA	820730	820729	-1	195.9	NEG
FIDELITY UNION BANCORPORATION	6025	NY	830727	830725	-2	197.0	NEG
FIRST & MERCHANTS CORP	6711	NA	830218	830217	-1	324.9	NEG
FIRST BANKSHARES CORP SC	6711	NA	830906	830902	-1	174.2	NEG
FIRST CHARTER FINL CORP	6122	NY	830112	830111	-1	804.8	NEG
FIRST COLONY LIFE INS CO	6311	NA	820113	820111	-2	268.7	NEG
FIRST UNITED BANCORPORATION INC	6711	NA	820503	820430	-1	282.9	NEG
FLAGSHIP BANKS INC	6711	NA	830510	830506	-2	285.2	BID
GIRARD CO	6711	NA	820803	820730	-2	223.7	NEG
HERITAGE BANCORPORATION	6711	NA	831004	830930	-2	170.9	NEG
JEWEL COMPANIES INC	5411	NY	840601	840531	-1	875.4	BID
LINCOLN 1ST BKS INC	6711	NA	831222	831221	-1	249.0	NEG
MIDLANDS ENERGY CORP	1311	NY	840914	840912	-2	249.9	NEG
MORAN ENERGY INC	1381	NY	831003	830930	-1	213.3	NEG
N L T CORP	6711	NY	820419	820415	-2	1593.7	BID
NATIONAL CENTRAL FINANCIAL CORP	6711	NA	820911	820910	0	339.5	NEG
NATOMAS COMPANY	1382	NY	830523	830520	-1	1354.5	BID
PAY N SAVE CORP	5912	NA	840904	840831	-1	358.0	BID
PEAVEY COMPANY	2041	NY	820420	820416	-2	177.0	NEG
PENNCORP FINANCIAL INC	6711	NY	820902	820831	-2	264.0	NEG
PETROLANE INC	5984	NY	840622	840620	-2	1044.5	NEG
PRAIRIE PRODUCING CO	1311	NY	841108	841107	-1	142.5	NEG
R I H T FINANCIAL CORP	6711	NA	831123	831121	-2	125.6	BID
REPUBLIC FINANCIAL SERVICES INC	6321	NY	820824	820820	-2	320.5	NEG
RYAN INSURANCE GROUP INC	6411	NA	820706	820701	-2	163.9	NEG
SECURITY NY STATE CORP	6711	NA	830404	830331	-1	108.7	BID
SEDCO INC	1381	NY	840914	840913	-1	1055.9	BID
SHELL OIL CO	2911	NY	840125	840123	-2	5467.9	BID
SIGMOR CORP	5541	NA	820707	820706	-1	160.0	BID
SOUTHWEST FLORIDA BANKS INC	6711	NY	831027	831026	-1	298.6	NEG
SUPERIOR OIL CO	1311	NY	840312	840309	-1	5725.8	NEG
TRANSPORT LIFE INS CO	6311	NA	820527	820525	-2	144.7	NEG
WOODWARD & LOTHROP INC	5311	NA	840430	840427	-1	222.9	NEG

4.7.2 Target Firms for the Period of 1989-1991

TARGET FIRM	SIC	EXCHANGE	ANNOUNCEMENT DATE WSJ/NYT/MR	ANNOUNCEMENT DATE ADJUSTED	ANNOUNCEMENT DATE ADJUSTMENT	TRANSACTION ($MILLIONS)	TYPE
APPLE BANCORP INC	6036	NY	900328	900327	-1	121.2	BID
BANKS IOWA INC	6711	NA	900807	900803	-2	272.0	NEG
C & S SOVRAN CORP	6712	NY	910626	910625	-1	4231.0	NEG
C V N COMPANIES INC	5961	NA	890627	890623	-2	380.0	NEG
CENTRAL PACIFIC CORP CA	6712	AM	890922	890921	-1	159.8	NEG
COAST FEDERAL SVGS & LN ASSN	6711	NA	890125	890124	-1	196.7	BID
D W G CORP	6711	AM	890313	890310	-1	361.9	BID
DIVERSIFIED ENERGIES INC DE	4924	NY	900731	900727	-2	655.0	NEG
DURHAM CORP	6311	NA	910417	910416	-1	300.6	BID
EQUITABLE BANCORPORATION	6711	NA	890713	890711	-2	542.0	NEG
EXCHANGE BANCORP INC	6711	NA	890727	890725	-2	380.5	NEG
F N W BANCORP INC	6025	NA	910326	910325	-1	202.0	NEG
FIRST ILLINOIS CORP	6711	NA	910604	910531	-2	340.1	NEG
FIRST INTERSTATE CORP WI	6025	NA	890919	890915	-2	199.7	NEG
FIRST OHIO BANCSHARES INC	6711	NA	890808	890807	-1	178.0	NEG
FIRST SECURITY CORP KY	6711	NA	911129	911125	-3	195.6	NEG
FLORIDA NATIONAL BANKS FL INC	6711	NA	890308	890306	-2	721.1	NEG
GENERAL NUTRITION INC	5499	NY	890630	890629	-1	360.1	BID
GLENMORE DISTILLERIES CO	2085	AM	910712	910710	-2	103.0	NEG
GOLDEN VALLEY MICROWAVE FD INC	2099	NY	910422	910419	-1	460.7	NEG
GORDON JEWELRY CORP	5944	NY	890525	890523	-2	297.8	NEG
HAMILTON OIL CORP	1311	NA	910207	910205	-2	525.3	BID
HEARTFED FINANCIAL CORP	6711	NA	900718	900717	-1	107.8	NEG
LA JOLLA BANCORP	6025	AM	891027	891025	-2	103.7	BID
LOUISIANA GENERAL SERVICES INC	6711	NY	900522	900518	-2	126.8	NEG
MANUFACTURERS HANOVER CORP	6025	NY	910716	910712	-2	1978.9	NEG
MANUFACTURERS NATIONAL CORP	6711	NA	911029	911025	-2	1103.8	NEG
MERCHANTS NATIONAL CORP	6711	NA	911031	911029	-2	644.7	NEG
OFFICE CLUB INC	5943	NA	901221	901219	-2	138.2	NEG
PACIFIC FIRST FINANCIAL CORP	6122	NA	890207	890203	-2	202.2	NEG
PACIFIC RESOURCES INC HI	2911	NY	890109	890106	-1	327.1	NEG
PYRO ENERGY CORP	1381	NY	890609	890607	-2	169.3	NEG
SCOTTYS INC	5211	NY	890410	890407	-1	139.3	BID
SECURITY BANCORP INC MI	6711	NA	910913	910911	-2	427.2	NEG
SECURITY PACIFIC CORP	6711	NY	910813	910809	-2	3895.1	NEG
SOUTH CAROLINA NATIONAL CORP	6025	NA	910621	910619	-2	798.2	NEG
ULTRA BANCORPORATION	6056	NA	890223	890221	-2	230.1	NEG
UNITED BANKS COLORADO INC	6711	NA	900711	900710	-1	378.2	NEG
WHOLESALE CLUB INC	5999	NA	901107	901105	-2	164.0	NEG
WILLIAMS A L CORP	6311	NY	890612	890609	-1	407.7	BID

Chapter Five

CONCLUSIONS AND FUTURE RESEARCH

To understand the social consequences of insider trading and how best to regulate it, this thesis examined two issues that are important to the resolution of the debate on insider trading: the effects of insider trading on stock prices and the compensation to insiders for providing information and other related services.

Whether insider trading reveals inside information is an important step in assessing whether insider trading contributes to overall economic efficiency. If information were not revealed to the market, then insider trading would not contribute to the informational efficiency of the stock market, thereby eliminating arguments in favour of insider trading based on informational efficiency. If information is fully or partially revealed to the market, then it is possible that insider trading will enhance overall economic efficiency. In this thesis, we have shown that inside information is partially revealed to the market. Our results do not support either the non-revelation theory or the full revelation theory.

One problem with empirical work on the informational consequences of insider trading is that it is difficult to separate the price effects induced by insider trading from the price effect induced by other factors. In this thesis, we employed a particular research design that enabled us to filter out the price effects induced by factors other than insider trading, thereby attributing the observed changes in price movements to changes in illegal insider trading. This method appears to be an effective way to analyze market responses to activities that are not directly observable.

As we have pointed out earlier, information revelation is only one important step towards the understanding of the informational role of insider trading. The question of whether informational efficiency indeed leads to greater economic efficiency is still to be resolved.

It is argued that compensation to insiders plays an important role in some corporate activities that require insiders to participate and contribute. Some theoretical models have demonstrated that without being sufficiently compensated by means of insider trading profits, insiders would not be motivated to engage in those corporate activities which create social benefits. We investigated whether insiders associated with acquiring firms seek fewer but more profitable takeovers after the introduction of tighter regulations. This is a direct test of whether insider trading profits are part of the compensation of insiders for undertaking the takeover project. We found that in the case of negotiated takeovers, tighter regulations lead bidders to seek more profitable takeovers. This evidence suggests that, in the case of negotiated takeovers, insiders do view insider trading profits as a part of their compensation for undertaking a takeover project. In the case of takeovers initiated by bidding, however, we did not find evidence that the tightened regulations resulted in bidders seeking more profitable takeovers. We conjectured that in this case the evidence might be due to the possibility that bidders are able to substitute legal trades for illegal trades by altering the timing of their trades.

We also investigated whether the regulatory changes had more impact on insider trading during negotiated takeovers than on insider trading during takeovers initiated by bidding. We argued that negotiated takeovers are more vulnerable to information leakages, because negotiations are less secretive than bidding. Furthermore we argued that insider trading during negotiated takeovers is more vulnerable to regulations, because insiders associated with negotiated takeovers do not control as much the timing of the takeover process as those involved in takeovers initiated by bidding. Consequently, it is difficult for insiders involved in negotiated takeovers to substitute legal trades for illegal trades. We found strong evidence that regulatory changes had more impact on negotiated takeovers than on takeovers initiated by bidding. We also found some evidence that in takeovers initiated by bidding the pre-announcement price run-up started earlier which implies perhaps a switch of insider trades to earlier periods to avoid threats of prosecution.

The evidence that insider trading regulations have different effects on illegal insider trading associated with different types of takeovers perhaps can be viewed as an indication that the current regulations have not quite captured the delicate differences of insider trading involved in different corporate events. It seems that, in certain circumstances such as takeovers initiated by bidding, the regulations on insider trading are not as effective as in other circumstances.

More generally, our evidence on the costs of regulations and the different response to regulatory changes of different types of takeovers suggests that insider trading regulations might have to be refined according to the circumstances in which insider trading arises. Insider trading associated with different corporate activities may well have different social consequences. There are still many other kinds of corporate activities that need to be analyzed with respect to the role played by insider trading.

With regard to the effectiveness of regulatory changes, we found that the tightening of insider trading regulations in the 1980's was effective in the sense that it has reduced insiders' purchase of shares of the target prior to the takeover announcement. This is in contrast to earlier studies on the effects of regulatory changes for approximately the same time period. We attributed the difference to our research design that eliminated most other effects and captured mainly the effects of illegal insider trading.

It should be noted that much of our conclusion on information revelation was based on some conjectures with respect to equilibrium price formation. Recall that we have assumed that the equilibrium price reflects a weighted average of the opinions of those traders with inside information and those traders without inside information. While this assumption appears reasonable, it would be desirable to develop its theoretical foundations.