Chapter 6

From Modern Astronomy to Modern Finance: A New Theory of Finance

6.1. What Finance and Astronomy Have in Common?

Some theories, originated from a very technical area, because of their deep insight and analytical power, become the foundation of much broader fields. Modern astronomy, founded by Copernicus, Kepler, Newton and others, was originally developed to understand the movements of several planets. Rational mechanics, the physical foundation of modern astronomy, later became the foundation of all modern science. Starting from 1870, Jevons, Walras and others applied the principle of rational mechanics to establish neoclassical economic theory. Today the philosophy and techniques originated from modern astronomy become the foundation of both natural science and social science.

In this chapter, we will examine the parallels between finance and astronomy to understand why the progress in financial research will revolutionize the whole foundation of social science. In the process, we will build up a new theory of finance.

We will discuss several common properties of finance and astronomy that make them the pioneer subjects that trigger much deeper changes in the foundation of sciences.

First, both the study of astronomy and finance are heavily data driven. Astronomy is the oldest precise science. Data of celestial observation have been accumulated over thousand of years. As observation became more accurate over time, it became easier to test alternative theories. Financial data are the most frequently and abundantly recorded data set. For each stock, each transaction price, bid-ask price, the size of the trade, and many other information are recorded on computerized systems. The abundance of real time financial data makes financial theories much easier to test than economic theories, since economic data are less frequent, less reliable and often subject to different interpretation.

The second is the simplicity of astronomy and finance. Astronomy, which Wiener (1948) termed as “an ideally simple science”, studied the orbits of isolated planets with little disturbance from other sources. Finance studies cash flows under uncertainty or price innovation of market securities, abstracted from all the intrigues of social and organizational complexities. Although many complicated forces are at work in the financial market, the low transaction costs determines that prices alone already reflect most of the interaction of these forces.

The simplicity of astronomy and finance makes the alternative theories easy to test. In astronomy, two alternative theories at the time were the earth centered universe and the sun centered universe. As the data became very accurate and sophisticated mathematical tools were developed, the alternative theories became easy to test. In finance, the default theories are the irrelevance of financial structure in corporate finance and efficient market theory in investment. Both theories are empirically testable. This is in sharp contrast to the general economic theory,

where utility function can be defined in many different ways. It is difficult to test whether economic agents maximize "utility" because it cannot be precisely defined (Mirowski, 1989).

Third, it is usually in simple subjects where sophisticated mathematical theories are developed and applied with great effectiveness. Calculus was invented by Newton to calculate the planet orbits. Before the invention of calculus, the calculation of nonlinear curves was almost impossible. After calculus was invented, the same calculation can be performed by any competent person with proper training. In social sciences, the complex relationship often prevents the development of sophisticated mathematical tools that are relevant and effective. In finance, however, the simplicity of research subjects enables people to develop mathematical models with deep analytical power and far reaching consequences. While calculus was first invented to calculate nonlinear planet orbits, stochastic calculus was successfully applied to solve the nonlinear payoff problems in options by Black and Scholes (1973).

Fourth, both astronomy and finance are of immense practical value. A new theory doesn't grow from vacuum. Before a new theory germinates, there always exists an established paradigm in any area of research. Before Copernican theory, theology was the foundation of the cosmology. Currently, general equilibrium theory is the foundation of economics and finance. Given the dominant status of theology then and the neoclassical economics today, why Copernican theory in astronomy and new theories in finance, such as behavioral finance, got established. This is because both astronomy in Copernicus' day and finance today have tremendous practical values. People tend to neglect the ideological differences on issues of practical values. For example, in general economic theory, dissident opinions rarely surface in major economic journals, although the problems of neoclassical economics are apparent to many people. In finance, however, papers on alternative theories, such as behavioral finance, have already occupied top tier finance journals for a long time.

Fifth, both astronomy and finance were pure mathematical theories initially but gradually turned to physics. Astronomy was a part of mathematical science in the ancient time. But starting from Kepler, people looked for physical causes to offer a unified understanding of celestial movements. (Voelkel, 2001) Eventually, Newton established the universal gravitational laws to unify the understanding of not only celestial bodies but also objects on earth. Financial theories are predominantly mathematical today. However it has been shown recently that the analytical thermodynamic theory of social sciences can be developed based on the techniques similar to those of Black-Scholes option pricing theory. (Chen, 2000, 2002b)

The simplicity of research subjects, the objectivity of research methodologies and powerful mathematics enabled the researchers in astronomy to break into the dominant paradigms of the time: the earth centered universe. In the process, a physical theory, rational mechanics, was developed to understand much broader phenomena. Since then, rational mechanics has become the dominant paradigm in natural science and social science. These same qualities in financial research help us establish a new paradigm: the analytical thermodynamic theory in social science and life science.

In Section 6.2, we will describe the trajectory of thinking from modern astronomy to modern finance and how the development of modern finance eventually offers a fertile ground for a new paradigm in social sciences. In Section 6.3 and 6.4, we will develop new theories of corporate finance and investment.

6.2. From Modern Astronomy to Modern Finance: A Brief Review

As inhabitants of the earth, we naturally think that the earth is the center of the universe. Since ancient time, people noticed that several planets, Mercury, Venus, Mars, Jupiter and Saturn, move in irregular ways while all stars move in perfect circles. It was thought that these planets were imperfect. To describe the orbits of these planets, many epicycles were needed. What is worse, as the observation became increasingly accurate, the models that were used to describe the

movements of the planets had to became increasingly complex as well. This theoretical difficulty made it possible for new theories to emerge (Kuhn, 1996). Copernicus proposed a new theory of astronomy, in which the sun was the center of the universe and the planets, including the earth, move around the sun. In a sun centered universe, the movements of planets became much simpler. But more importantly, the new theory made it possible to attribute the movements of planets from a universal physical force. At that time, people already knew that the sun was much larger than the planets. This sun centered theory inspired Kepler to conjecture that all planets were attracted by some force from the sun. This idea turned astronomy from a purely mathematical theory into a physical theory. Since all planets were driven by a unified force, their movements must follow some simple laws, Kepler conjectured. Eventually Kepler was able to show that the movements of all planets follow three simple laws: the Kepler's Laws. (Voelkel, 2001) Newton further showed that the movements of planets can be derived from gravitational law and his three Laws of Motion. So the "imperfectness" of planets comes from our understanding of planets but not from planets themselves.

Furthermore, "Newton presented his three Laws of Motion, which applied celestial and terrestrial behavior alike. Here was another revolution, for it sealed the doom of the long-held belief that those two realms were different." (Schorn, 1998, p. 34) The success of rational mechanics to offer a unified theory on celestial and terrestrial behavior encourages people to apply it to broader fields, including social sciences.

The pioneers of neoclassical economics, such as Jevons and Walras, attempted to transform economics into a rigorous science based on rational mechanics. From there, rational expectation theory and optimization theory was developed. In neoclassical economics, rational individuals try to maximize their utility. The interaction of all individuals ends up in a general equilibrium state. A major problem of this theory is that utility is usually difficult to measure or even define. (Mirowski, 1989)

Finance is a part of economics. There are two major branches in finance: corporate finance and investment theory. In corporate finance, the theoretical foundation is Modigliani and Miller theorem, which states that financial structure of a firm is irrelevant to its value in a perfect market. In investment theory, the main theory is the efficient market theory. Unlike utility maximization theory in economics, both capital structure irrelevance theory and efficient market theory are empirically testable and are the subjects of investigation in many research works.

Empirical evidences demonstrate that financial structures are relevant for corporations. This relevance is often attributed to market imperfection. If an imperfection is identified, this type of imperfection would be gradually reduced over time from competition or regulation. So we might expect capital structures of firms will be less and less relevant and financial decision making becomes simpler and simpler over time. Fifty years ago when Modigliani and Miller first published their paper, theories and practices in finance were relatively simple. Since then, problems in corporate finance, instead of getting simpler and simpler, have become more and more complicated. In the process, many complex financial instruments, such as convertible bond, which is a hybrid of debt and equity, have been created in the financial markets. Number of finance professionals also increase tremendously in the last fifty years. All these indicate that the relevance of financial structure is not a matter of market imperfection but of more fundamental reasons.

With few exceptions, tests on efficient market theory are joint tests on asset pricing models. (Chen, 1999, 2003) The standard asset pricing model is Capital Asset Pricing Model (CAPM). The beauty of CAPM is that it offers a conceptually simple and testable relation between risk and return. As empirical results accumulate, it becomes clear that the relation predicted by CAPM doesn't hold in the asset markets. Many new models, often containing three or four factors, are developed to fit data better. However, these increasingly complex models have lost the simple property of risk return tradeoff in the original CAPM theory. This is very much like astronomy in Copernicus' day. The original Ptolemy system was a very elegant model. The

earth is near the center of the universe. All celestial bodies move around the earth in circles. As the astronomical observation became more accurate, it became clear that planets didn't move around the earth in circles. Astronomers developed more complex models of circles over circles to fit the observed data better. While these new models fit the data very well, they lost the beauty and simplicity of the original Ptolemy model. What is worse, as the observation became progressively more accurate, the models had to became progressively more complicated to fit the data. This pattern seems to repeat itself in today's financial researches. As data accumulate, asset pricing models become progressively more and more "sophisticated".

As problems mount, we need to reexamine the very foundation of corporate finance theory and investment theory.

Miller states, "The M&M propositions are the finance equivalents of conservation laws" (Miller, 1991, p. 483). From the theory of conservation laws, entropy condition has to be introduced to obtain realistic solutions (Smoller, 1994). So the concept of entropy emerges naturally from conservation laws.

Efficient market theory states that market can process information instantly. From Maxwell (1871) and Shannon (1948), information is the reduction of entropy. So a study of market behavior needs a better study of information as entropy.

In both corporate finance theory and investment theory, the concept of entropy emerges naturally from discussion. While theories based rational mechanics do not offer clear understandings about problems in finance, we demonstrate in the next two sections that theories based on thermodynamics do offer simple and consistent understanding of financial problems.

6.3. A New Theory of Corporate Finance

Since Modigliani and Miller (1958) presented the result on capital structure irrelevance in a perfect market, researchers have searched for imperfections in the capital market and how these imperfections determine the capital structure in real life. Fama and French (2002) summarized the current state of research:

> The finance literature offers two competing models of financing decisions. In the tradeoff model, firms identify their optimal leverage by weighing the costs and benefits of an additional dollar of debt. The benefits of debt include, for example, the tax deductibility of interest and the reduction of free cash flow problems. The costs of debt include potential bankruptcy costs and agency conflicts between stockholders and bondholders. At the leverage optimum, the benefit of the last dollar of debt just offsets the cost. …Myers (1984) develops an alternative theory known as the pecking order model of financing decisions. The pecking order arises if the cost of issuing new securities overwhelm other costs and benefits of dividends and debt. The financing costs that producing pecking order behavior include the transaction costs associated with new issues and the costs that arise because of management's superior information about the firm's prospects and the value of its risky securities. Because of these costs, firms finance new investments first with retained earnings, then with safe debt, then with risky debts, and finally, under duress, with equity. As a result, variation in a firm's leverage is driven not by the tradeoff model's costs and benefits of debts, but rather by the firm's net cash flows (cash earnings minus investment outlays). (Fama and French, 2002, p. 2)

While some empirical patterns can be explained by tradeoff and pecking order theories, many questions remain unanswered. For example, Miller once commented:

> The standard finance explanation that we were seeing a conscious and well-considered tradeoff between the tax benefits of borrowing and the expected costs of bankruptcy was hard to take seriously. The relative numbers were just too far out of line. Firms in 1976 were throwing at

the government $40 billion in corporate taxes, a sum that would cover the true deadweight costs of all bankruptcies for decades. There had to be something else at work. (Miller, 1998, p. 116)

Before we show how our theory can provide parsimonious understanding of the empirical results, we discuss the concept of "imperfection".

If the relevance of capital structure is caused by some kind of market imperfection, it would be reduced gradually. Over time, financial decisions will become less and less important. But finance theory and practice has become more and more important since M&M first propose their theory about fifty years ago. Some start to question whether "imperfections", such as agency costs can account for the observed patterns of capital structure:

The possibility that managers might let their own interest override that of the shareholders was something that Franco Modigliani and I were certainly aware of back in 1958 and through all our subsequent revisions and extensions; and we knew that anecdotal evidences of non-value maximizing behavior by under-diversified managers would always easy to come by. But we doubted that such nonoptimizing behavior would lead to *systematic* departures from the model. We believed that the stock holders would learn to solve, or at least greatly to mitigate any excessive risk aversion of their managers by appropriate compensation and incentive mechanisms. The stockholders, after all, could always persuade the managers to act more like stockholders by giving the managers stock or stock appreciation rights or stock options of any of the a number of kinds. Given the defenses available to stockholders to recapture value they believe belongs to them --- including defenses such as large-shareholder influence and hostile takeover by outsiders --- it is hard to believe that a sum as large as $150 billion a year would be left lying on the table. (Miller, 1998, p. 118)

M&M theory becomes the standard theory in corporate finance because it is logically consistent. There could be, however, many different logically consistent theories. For example, both earth centered theory and sun centered theory about our universe are logically consistent. But sun centered theory gives a simpler description of the movements of the planets. In earth centered theory, the movements of planets are very imperfect. In the new theory of sun centered universe, the planets move perfectly according to Kepler's laws. Very often, "imperfection" of some empirical patterns leads to the discovery of new and unified theories.

A theory of corporate finance is built on a theory of the firm (Zingales, 2000). After analyzing the shortcomings of current theories of the firm, Zingales stated that a new theory of the firm should answer the following questions:

How does an organization succeed in acquiring power that differs from ordinary market contracting? How is this power maintained, enhanced, or lost? How is this power used in a way that differs from ordinary market contracting? How is the surplus generated by the firm divided among its members? (Zingales, 2000, p. 1651)

We will show how the theories developed in this book will provide a new theory of firm that gives simple and coherent answers to these questions.

An organization succeeds in acquiring power that differs from ordinary market contracting because of some information advantage. From Formula (1.3),

$$R = H(x) - H_y(x)$$

the amount of information one can receive depends on the background knowledge of receiver. Those who understand information better can utilize information better. The production of a good

needs fixed assets and variable costs, which is a function of fixed cost and rate of diffusion. A firm's competitive power comes from its internal structure that reduces diffusion in the production process. Formula 1.3 explains the function and stability of firms. In a firm, because of the common knowledge of many details of the business, $H_y(x)$, the equivocation is small and the information flow is more fluent, which reduces transaction cost (Coase, 1937). If a person's talent is of amount $H(x)$, the value that is appreciated by others is $H(x)-H_y(x)$. In another firm that people are less familiar with his knowledge, equivocation is high. A person is usually valued higher in his current position than in a potential new position in other firms. That explains the relative stability of employment and long-term stability of firms (Arrow, 1999). Since the common knowledge and custom of a firm is built over a long time, market cannot replicate its structure instantly. That is how a firm acquires power that different from ordinary market contracting.

The power of a firm can be maintained or enhanced by further reducing diffusion or by increasing fixed cost, both reducing variable costs. The detailed operation should depend on market conditions. For example, if market size increase, the firm should increase fixed costs. (Figure 3.2) Established firms often lose market power in a fast changing environment since the existing fixed assets make it less adaptive in a new environment than small and new firms. (Figure 3.1)

Whether a company decides to develop and produce something in house or contract out by market transactions depends on several factors. First, it depends on how existing facilities are compatible with the new products. If simple modification or extension of existing facilities can help produce the product, the company probably will produce in house. That is, if the existing fixed assets can help reduce variable costs in the production, it will produce in house. Otherwise, it will contract out. Second, it will depend on the value of the product. From the value theory developed in Chapter 2, if many companies can product the product, its value is low. Contracting out will not reduce the company's competitive power and will keep the company flexible in future developments.

A corporation is a collection of assets. Although shareholders are nominally the owners of these assets, they own the assets only to the extent they can effectively control the assets. While incentives may be designed to align management interest with shareholders' interest, the only way the management interest completely align with shareholders is for management to completely own the companies, that is, shareholders relinquish all their claims. Therefore a better alignment is more costly. Inside a company, management cannot monitor everything. They have to delegate responsibility to other employees, which creates information asymmetry. So every employee owns part of the company. So are some large customers and suppliers.

How the surplus generated by the firm divided among its members will depends on the power structure of the firm. If top manager are major shareholders who understand businesses very well, which is typically the case in small and new firms, major portion of surpluses will be retained by the shareholders. If the ownership is very diffuse and top managers have very little share ownership, which is typically the case for large, mature firms, managers and employees retain higher shares of surpluses. This is why pay and benefit in large companies are generally better than in small companies.

We then present the new theory of capital structure, which is a combination of information theory and production theory. Information theory alone can derive the pecking order model, that firms finance new investments first with retained earnings, then with safe debt, then with risky debts, and finally, with equity. From Figure 3.1 and 3.2, fixed cost, or operating leverage, matters to the performance of a company. For the same reason, capital structure, or financial leverage, matters to the performance of a company. Production theory indicates that firms should choose a proper combination of fixed cost and variable cost to achieve highest rate of profit. Since debts are fixed income instruments for investors, they are fixed costs for issuers. From the production theory, high fixed cost systems perform well in a low uncertainty

environment and perform badly in a high uncertainty environment. So we expect small growth firms, which are of high uncertainty, to be heavily financed by equities instead of debts. This prediction differs from the pecking order theory and is confirmed by empirical results (Fama and French, 2002). In general, firms with high fixed costs in operation, such as heavy R&D spending, may choose lower fixed cost strategy in financing, to reduce the impact of uncertainty on the performance of the firms (Titman, 1984). Firms operating in low level of uncertainty, such as utility firms in regulated environment, will be financed with high level of debt to increase their fixed costs, or financial leverage.

In the original Modigliani and Miller (1958) paper, the value of a firm, in the sense of the total value of its securities, depends only on the earning power and risk of its operating assets and not at all on the debt/equity composition of the liabilities. Later works add financial risk into the picture since operating risk is related to financial risk. In this theory, financial risk and operating risk are integrated into a single analytical model so that operating leverage and financial leverage can be considered together. The following discussion shows that this unified approach greatly simplified the understanding of financing decisions.

In the tradeoff theory, the cost of debt is essentially the cost of bankruptcy. Miller (1998) had pointed that the cost of bankruptcy is too small to justify the low debt ratio. In the new theory, variable cost of operation is a function of fixed cost and uncertainty, which are affected by the debt level. So the level of debt, by affecting fixed cost and variable cost of operation, has much broader impact on firms than the cost of bankruptcy. This is why firms do not fully utilize the tax advantage of debt financing.

6.4 A New Theory of Investment

Currently, the default theory of investment is the efficient market theory, which states that stock market incorporates new information instantly and hence stock prices always reflect the true value of the underlying companies. The standard economic theory of information was developed by Grossman and Stiglitz (1980). This theory is based on rational expectation. It assumes that investors can accurately assess the value of some information and pay some fixed amount accordingly to obtain the information. Recently, various models relax the rational expectation assumption to explain major market patterns. Most of these models rely on some kind of human psychological biases and are generally grouped under the category of behavioral finance.

To date, behavioral asset pricing models have been more ad hoc, mainly constructed to provide behaviorally based explanations of particular empirical phenomena, rather than to develop a general approach.

The ad hoc approach that has characterized most behavioral asset pricing theories to date has a theory mining flavor, mainly building custom models to fit the empirical facts. These models have tended to combine one or two behaviorally realistic assumptions with other assumptions that are highly unrealistic. (Shefrin, 2005, p. 5)

More importantly, formal asset pricing models in behavioral theories are still based on general equilibrium theory. In Chapter 1, we showed that major psychological patterns frequently cited in behavioral finance literature can be naturally derived from the principles of statistical mechanics and natural selection. In this section, we will show that the generalized entropy theory of information developed in Chapter 1 will provide parsimonious understanding of major market patterns and trading behaviors of market participants.

First, since information with higher value is more costly, only large investors will spend time and resources to acquire valuable information. Hence, the return of small investors should be lower than the return of large investors and the general market index, which is the average of all investors.

The above result may be called the generalized efficient market hypothesis: investors without informational advantage, who compose the majority of investors, can not outperform the general market. Empirical results indicate that small investors' returns are harmed by active trading or active choices in investment vehicles (Barber and Odean, 2000; Cronqvist and Thaler, 2004).

This result has very strong social implications. Economists generally believe that individuals are best equipped to choose what is in their best interest and more freedom will increase social welfare. The new theory and the supporting empirical evidences, however, cast doubt over this strongly held belief.

It is not economical for small investors to spend a lot of effort to study individual stocks. Can they expect superior returns by investing in mutual funds with talented managers? The information theory predicts that the value generated by the talented managers will be mainly retained by the managers, who spend time to collect and analyze information, and not be distributed to mutual fund investors, who mostly have limited means to uncover valuable information. For example, as the average transaction costs decrease over the years, average expense ratios increase, making the sum of these two costs remaining relatively constant over the years (Wermers, 2000). Wermers also noted that during the 1977 to 1994 period, mutual funds returned an average of 13.3 percent per year to investors, which is the same as the Vanguard fund, the largest index fund. In essence, for small investors without special information advantage or people whose cost of collecting and analyzing information outweighs its benefit, which are the majority of the population, they cannot expect a higher rate of return on stocks than the general market. This statement is the same as what have been prescribed from the efficient market theory. For large investors or investors with special informational advantages, their investment strategies or corporate strategies can be very different

Second, from Formula (1.3), understanding information is easier when receivers have lower level of equivocation. This indicates that investors will earn higher rate of return if they choose to invest in securities that they are familiar with. This is supported by some recent empirical investigations. Professional managers' and individual investors' local investments outperform their remote investments (Coval and Moskwitz, 2001; Ivkovic and Weisbenner, 2005). Mutual funds with high industry concentration, where fund managers can focus on particular industries they are familiar with, are more successful in selecting securities than diversified funds (Kacpercyzk, Sialm and Zheng, 2005).

This information theory and empirical evidences challenge the current theory of wide diversification in security investment. From the theory, if one has informational advantage in certain area, she should relatively concentrate her investment in that particular area to earn higher rate of return. Otherwise, she should diversify to reduce her risk.

Third, the gradualness for the investment public to understand corporate investment and strategy will produce systematic patterns in return and trading volume. Many of these patterns cannot be explained by current behavioral literature (Lee and Swaminathan, 2000; Hvidkjaer, 2001). However, they can be explained easily by this information theory. The detailed exposition is developed in Chen (2004). Here we will give a brief description of the patterns.

To an investor, the choice of information gathering is a matter of cost. More valuable information is more costly to obtain in general. For large investors, it pays to spend a lot of effort and money to research the fundamentals. For small investors, it doesn't pay to dig into the fundamentals. They depend on processed and easy to understand information that is readily available at low cost, such as news from popular media and price movement of the shares. When an investor will be able to access a certain information also depends on her particular background, which determines her level of equivocation in receiving that information. In the following, we will illustrate the patterns of return and trading volumes of a stock of a typical company from the information processing cycle.

Suppose a company develop a new technology, which is expected to bring the company high profit in the future. From Formula (1.3), those who are familiar with the technology and company will have low equivocation in receiving the information. They understand the significance of the information first and buy the company shares. Since they are a small number of people, the trading volume is low.

As the technology goes through various stages from R&D to production, the potential becomes clearer to more people. This means that the level of equivocation gradually reduces to more people, which sustains buying interest and share prices increase gradually. As the technology becomes adopted in production and profit figures become public, the level of equivocation decrease further and the pool of investors increases further. Eventually, both the sustained increase of stock price and stable pattern of profit increase, which are very easy to understand by the general public, attract large amount of buyers, which results high trading volume and push the stock prices further up.

From Figure 1.1, the value of some information that is known to everyone is zero. As the good news reaches most investors, the security is probably already fully or over priced. Among the increased pool of investors, more and more investors understand very little of the fundamentals behind the technology and depend on easy to understand signals such as coverage from popular media and stock price movement to make trading decisions. For this group of investors, they will stop buying only when the opinion of public media changes and the trend of price increase reverses significantly. As stock price keeps increasing, momentum trading becomes highly profitable, which will eventually push the share prices higher than the fundamental value. Since large investors spend more resources in investment, they are generally better informed than small investors. As share prices become highly overvalued relative to fundamentals, large investors start to unload positions while small investors keep buying. As the selling pressure from large investors becomes greater than the buying pressure from small investors, the trend of price increase reverses to price decrease.

As the pattern of price drop becomes clear, more and more people joined the selling. After large investors and some of the small investors have finished unloading the positions, the volume of trading will decline, which is the period of low volume loser in momentum life cycle. This period is characterized by active selling of small investor (Hvidkjaer, 2001). Since small investors are typically slow to understand information, their active selling, after the selling by large investors, signals the selling is overextended, which indicates the low volume losers will rebound and earn high future return in general.

From the above discussion, positive new information from a company will produce a distinct cycle of market returns: At the first stage, share prices move up with low trading volume. At the second stage, share prices move up with high trading volume. At the third stage, share prices moves down with high trading volume, and at the last stage, share prices move down with low trading volume. Along the cycle, small traders are always at the wrong side of trading. This theory is supported by some recent empirical works (Lee and Swaminathan, 2000; Hvidkjaer, 2001).

Fourth, the differences in informational advantages can also explain some patterns in small investor trading behaviors. Odean (1999) documented that the shares individual investors sold outperform the shares they bought. He observed: “Return patterns after purchases and sales are more difficult to understand. It is possible that some of these investors are among the last buyers to contribute to the rise of overvalued momentum securities” (Odean, 1999, p. 1296). This observation is confirmed by the empirical work by Hvidkjaer (2001) on the trading behaviors of large and small investors and can be easily explained by the information theory, which indicates that small investors mainly depend on low cost and hence low value information, such as news and technical trends, which put them “among the last buyers to contribute to the rise of overvalued momentum securities”. Another reason for the differential performance of shares bought and sold by individual investors may be due to informational advantages of some of their

trading counterparties. Chen, Jegadeesh and Wermers (2000) documented that shares bought by mutual fund managers outperform shares they sold. Even if individual investors randomly select buy and sell orders, most trades that get executed are not in their favor, because some of their counterparties, such as mutual fund managers, have informational advantages and select to fill the orders that are in their favor. For example, if an individual investor randomly select two stocks to sell with limit orders, it is more likely that the stock which will have a higher rate of return in the future will be bought by more informed investors. This simple and intuitive understanding from information theory avoids the complex task of a behavioral explanation of: "What is more certain is that these investors do have useful information which they are somehow misinterpreting" (Odean, 1999, p. 1296).

Barber and Odean (2000) documented that there is very little difference in the gross performance of households that trade frequently and those that trade infrequently. On average, shares individual investors sold outperform the shares they bought. (Odean, 1999) If all else are same, more frequently traded investors should earn lower rate of gross return. So this indicates that more frequently traded investors have better investment skills than less frequently traded investors. This prediction can be directly verified from trading records. Barber and Odean cited Carhart (1997) to show that frequent trading also hurts the performance of mutual funds. However, a more recent and more detailed study by Wermers (2000) shows that the most active traded mutual funds outperform least traded mutual funds by a wide margin. Barber and Odean attribute trading activities to overconfidence, a behavioral explanation. It may be simpler and more consistent with empirical evidences to explain trading as a type of learning activity. Like all other kinds of learning, trading is costly. The cost of learning is compensated by knowledge gained from the experience.

Fifth, since insiders understand information much better than others, they can and will take advantage of this information asymmetry to pursue certain corporate activities. From what we discussed in the third point, shares of individual corporations and the whole market often go through undervaluation-overvaluation cycles. These under or over-valuation create opportunities for merger activities. Shleifer and Vishny (2003) develop a new model on corporate mergers, in which mergers are a form of arbitrage by rational managers operating in inefficient markets. They show that their model has better explanatory power than the behavioral based models and is supported by new empirical evidences (Ang and Zheng, 2002). While assuming managers are rational, they at the same time assume financial markets are less-than-rational. However, form the information theory, there is no need to assume financial markets are less-than-rational.

So this new theory of investment based on generalized entropy theory of information offers a unifying understanding of the documented empirical patterns in the financial markets.

6.5. Criteria for a Good Theory

Recent years, the standard theories in finance, such as Modigliani and Miller (1958) theory in corporate finance and efficient market theory in investment have retreated substantially. Many new theories have emerged and more new theories will emerge to fill the void left behind. With so many new theories around, it is time to consider some general criteria for a good theory.

First, a good theory should be consistent with empirical evidences. Not so long ago, empirical works on market behavior were so few that it was very difficult to distinguish the validity of different theories. In the past several years, however, we witness the emergence of a growing number of empirical works, which often call into the question of the ability of existing behavioral theories in explaining broader sets of empirical patterns. In the last section, we list these empirical results and show how the new information theory provides a simple and unified understanding of the empirical patterns. This theory resolves some puzzles about the market patterns raised in the recent literature that could not be answered by existing theoretical frameworks. In corporate

finance, both tradeoff and pecking order theories can explain part of the empirical patterns but our new theory is consistent with broad range of empirical patterns.

Second, a good theory should provide more precise predictive power than the existing theories. Kahneman and Tversky's prospect theory is an improvement over Simon's bounded rationality theory because it offered some concrete patterns of irrationality beyond the general statement of bounded rationality. Empirical evidences indicate that the patterns of trading by small, individual investors differ systematically from that by large, institutional investors. Yet the existing behavioral theories do not offer any particular behavioral explanations to this systematic difference. (Hvidkjaer, 2001; Shanthikumar, 2004) The new information theory, however, provide very precise understanding of the systematic differences between trading patterns of large and small investors. This information theory states that more valuable information is more costly to obtain in general. For large investors, it pays to spend a lot of effort and money to research the fundamentals. For small investors, it doesn't pay to dig into the fundamentals. They depend on processed and easy to understand information that is readily available at low cost, such as news from popular media and price movement of the shares. In this work, we will show that patterns of returns by small and large investors and patterns of return and trading volumes of stocks can be easily understood from this information processing perspective.

Third, a good theory should help provide deeper understanding to existing models. For example, Hong and Stein's (1999) results are built on three key assumptions. The first two assumptions are that traders are classified as "newswatchers" and "momentum traders" according to their information processing abilities. They commented that, "the constraints that we put on traders' information-processing abilities are arguably not as well-motivated by the experimental psychology literature as the biases in Barberis et al. (1998) or Daniel et al. (1998), and so may appear to be more ad hoc." (Hong and Stein, 1999, p. 2145) These assumptions can actually be derived naturally from this new information theory. Depending on the value of assets under management, different investors will choose different methods of information gathering with different costs. "Newswatchers" are large investors who are willing to pay a high cost to collect private information and to make a deep understanding of public information. "Momentum traders" are investors who spend less cost or effort on information gathering and rely mainly on easy to understand low cost information such as coverage from popular media and price momentum signals. Cohen, Gompers and Vuolteenaho (2002) empirically confirm that institutional investors buy on fundamental news while individual investors buy on price trends. The third assumption of Hong and Stein (1999) is that private information diffuses gradually across the newswatcher population. The gradual diffusion of private information means that people gradually learn about the background knowledge of information and understand information better over time. This new information theory provides clear understanding to all three assumptions in Hong and Stein's model.

The new information theory provides a clear understanding of pecking order theory and the production theory developed in Chapter 3 provides a clear understanding of tradeoff theory in corporate finance theory.

Fourth, a good theory should be consistent with theories in other areas or at more fundamental level. The financial market is often said to adjust to new information instantly because of intense competition. Since the intellectual market is highly competitive as well, one would expect it will adjust to new information in several years. However, it is well known that theories of fundamental importance are often neglected for many decades. (Khun, 1996) For example, Bachelier's theory had to wait more than half century before it got the attention. This is hard to reconcile with efficient market theory. However, it is logical from information theory. If a research result is an addition to a well established theory, it will be noticed and accepted immediately because of low level of equivocation. When a fundamentally new theory appears, however, the level of equivocation is high and the theory may take great effort to get accepted.

From the efficient market theory, a company's stock have high return because of some unforeseeable events that cannot be predicted. However, from the researches in business strategy, a company does well often because it persists in a good strategy for a long time before the competitors and the stock market react (Collins and Porras, 1994**).** Take Wal-Mart as an example. One of its most important strategies is to set up large discount stores in small communities. The early entry of one large store in a small community preempts the entry of other big stores. The resulting local monopoly ensures high level of profit. Since the value of information is positively related to scarcity, a player adopting a superior strategy will keep quiet about it. To keep a low profile, Wal-Mart avoided opening new stores where Sears and K-mart already had existence. This gave other giant retailers the impression that Wal-Mart was not very competitive. Hence other retailers will be less likely to imitate the strategies of Wal-Mart. In fact, the strategy of local monopoly in small rural communities was not copied by other giant retailers such as Sears and Kmart for a long time for they thought small communities are too small markets for big players. The extensive time lag in adopting a superior strategy from a competitor is not consistent with efficient market theory, but is a natural result from the generalized entropy theory of information.

6.6. Concluding Remarks

In Section 6.2, we stated that the increasing role of finance in the business world in the last fifty years indicates that the relevance of financial structure can not be explained away as market imperfection. In the last fifty years, the fixed costs of businesses have increased tremendously. From Figure 3.1, high fixed cost systems are very sensitive to uncertainty. Since the choice of financial structures affects the fixed cost of businesses, it is highly relevant to the operation of business, especially those with high fixed costs. As the levels of fixed cost increase in the businesses, the financial structures also become more relevant.

Most of the research efforts in financial markets are to reduce information asymmetry as investors. Will all research efforts improve the efficiency of the overall financial markets over time? While the information asymmetry of a mature company or industry may reduce over time, the information asymmetry of the whole financial market may not. The utilization of natural resources generally follows from easy to difficult among living organisms (Atkins, 1995). Similarly, the development of human industries generally follows from easy to difficult. As the technologies of mature industries become widely known and less valuable, competition pressure drives innovations and new industries. At time passes by, the new industries are generally more and more difficult to develop and more and more difficult for most people to understand. So information asymmetry may grow instead of decrease. Around year 2000, the stock prices of many of the high tech companies dropped over ninety percent in a short period of time, signaling the difficulty of the general investment public to understand the intricacy of the complex technological systems.

While there are several existing theories on IPO underpricing, it can be a measure of information asymmetry. "IPO underpricing doubled from 7% during 1980-1989 to almost 15% during 1990-1998 before reverting to 12% during the post-bubble period of 2001-2003" (Loughran and Ritter, 2004, p. 5). Figure 6.1 shows the annual average IPO underpricing in the US market since 1980. This offers an empirical measure that information asymmetry does trend upward in recent decades.

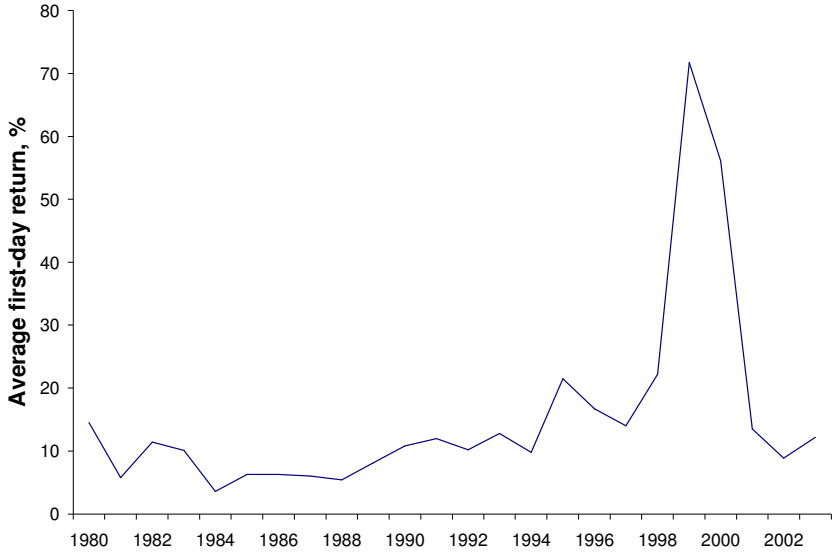

Figure 6.1 Average IPO underpricing in the US market since 1980. Source: Loughran and Ritter (2004)

This new theory of finance, like all other theories developed in this book, is still at an early stage of development. Many aspects of financial problems have not been discussed, which will be left to future research.