

Asset Pricing under Asymmetric Information
- Bubbles, Crashes, Technical Analysis and Herding -

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To Smita

Asset prices are driven by public news and information that is often dispersed among many market participants. These agents try to infer each others' information by analyzing price processes. In the past two decades, theoretical research in financial economics has significantly advanced our understanding of the informational aspects of price processes. This book provides a detailed and up-to-date survey of this important body of literature.

The book begins by demonstrating how to model asymmetric information and higher order knowledge. It then contrasts competitive and strategic equilibrium concepts under asymmetric information. It also illustrates the dependence of information efficiency and allocative efficiency on the security structure and the linkage between both efficiency concepts. No-Trade Theorems and market breakdowns due to asymmetric information are then explained and the existence of bubbles under symmetric and asymmetric information is investigated.

The book contrasts different market microstructure models that demonstrate how asymmetric information affects asset prices and traders' information inference. Optimal trading strategies are illustrated using dynamic models. These models provide a theoretical explanation for technical analysis and illustrate why some investors "chase the trend". The reader is then introduced to herding models and informational cascades which might arise in a setting where agents' decision making is sequential. The insights derived from herding models are used to provide rational explanations for stock market crashes. Models in which all traders are induced to search for the same piece of information are then presented to provide a deeper insight into Keynes' comparison of the stock market with a beauty contest. The book concludes with a brief summary of bank runs and its connection to financial crises.

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Chapter 0

Preface

Motivation

A vast number of assets changes hands every day. Whether these assets are stocks, bonds, currencies, derivatives, real estate or just somebody's house around the corner, there are common features driving the market price of these assets. Asset prices fluctuate more wildly than the prices of ordinary consumption goods. We observe emerging and bursting bubbles, bullish markets, and stock market crashes. Another distinguishing feature of assets is that they entail uncertain payments, most of which occur far in the future. The price of assets is driven by expectations about these future payoffs. New information causes market participants to re-evaluate their expectations. For example, news about a company's future earning prospects changes the investors' expected value of stocks or bonds, while news of a country's economic prospects affects currency exchange rates. Depending on their information, market participants buy or sell the asset. In short, their information affects their trading activity and, thus, the asset price. Information flow is, however, not just a one-way street. Traders who do not receive a piece of new information are still conscious of the fact that the actions of other traders are driven by their information set. Therefore, uninformed traders can infer part of the other traders' information from the current movement of an asset's price. They might be able to learn even more by taking the whole price history into account. This leads us to the question of the extent to which technical analysis or chart analysis is helpful in predicting the future price path.

There are many additional questions that fascinate both professionals and laymen. Why do bubbles develop and crashes occur? Why is the trading volume in terms of assets so much higher than real economic activity? Can people's herding behavior be simply attributed to irrational panic? Going beyond positive theory, some normative policy issues also arise. What are the early warning signals indicating that a different policy should be adopted? Can a different design of exchanges and other financial institutions reduce the risk of crashes and bubbles?

If financial crises and large swings in asset prices only affect the nominal side of the economy, there would not be much to worry about. However, as illustrated by the recent experiences of the Southeast Asian tiger economies, stock market and currency turmoil can easily turn into full-fledged economic crises. The unravelling of financial markets can spill over and affect the real side of economies. Therefore, a good understanding of price processes is needed to help us foresee possible crashes.

In recent years, the academic literature has taken giant strides towards improving our understanding of the price process of assets. This book offers a detailed and up-to-date review of the recent theoretical literature in this area. It provides a framework for understanding price processes and emphasizes the informational aspects of asset price dynamics. The survey focuses exclusively on models that assume that all agents are rational and act in their own self-interest. It does not cover models which attribute empirical findings purely to the irrational behavior of agents. It is expected that future research will place greater emphasis on behavioral aspects by including carefully selected behavioral elements into formal models. However, models with rational traders, as covered in this survey, will always remain the starting point of any research project.

Structure of the Survey

The main aim of this survey is to provide a structural overview of the current literature and to stimulate future research in this area.

Chapter 1 illustrates how asymmetric information and knowledge in general is modeled in theoretical economics. Section 1.1 also introduces the concept of higher-order knowledge which is important for the analysis of bubbles. Prices are determined in equilibrium. There are two different equilibrium concepts which are common in market settings with asymmetric information. The competitive Rational Expectations Equilibrium (REE) concept has its roots in the general equilibrium theory, whereas the strategic Bayesian Nash Equilibrium concept stems from game theory. The book compares and contrasts both equilibrium concepts and also highlights their conceptual problems. This chapter also introduces the informational efficiency and allocative efficiency concepts to the reader.

The first section of Chapter 2 provides a more tractable notion of common knowledge and the intuition behind proofs of the different no-trade theorems. The no-trade theorems state the specific conditions under which differences in information alone do not lead to trade. A brief introduction of the basics of asset pricing under symmetric information is sketched out in Section 2.2 in order to highlight the complications that can

arise under asymmetric information. In an asymmetric information setting, it makes a difference whether markets are only “dynamically complete” or complete in the sense of Debreu (1959), i.e. completely equitizable. Market completeness or the security structure, in general, has a large impact on the information revelation of prices. Section 2.3 provides definitions of bubbles and investigates the existence of bubbles under common knowledge. It then illustrates the impact of higher-order uncertainty on the possible existence of bubbles in settings where traders possess different information.

The third chapter illustrates different market microstructure models. In the first group of models, all market participants submit whole demand schedules simultaneously. The traders either act strategically or are price takers as in the competitive REE. The strategic models are closely related to share auctions or divisible goods auctions. In the second group of models some traders simultaneously submit demand/supply schedules in the first stage and build up a whole supply schedule in form of a limit order book. In the second stage a possibly informed trader chooses his optimal demand from the offered supply schedule. A comparison between uniform pricing and discriminatory pricing is also drawn. Sequential trade models à la Glosten and Milgrom (1985) form the third group of models. In these models, the order size is restricted to one unit and thus the competitive market maker quotes only a single bid and a single ask price instead of a whole supply schedule. In the fourth group of models, the informed traders move first. The classical reference for these models is Kyle (1985).

Chapter 4 focuses on dynamic models. Its emphasis is on explaining technical analysis. These models show that past prices still carry valuable information. Some of these models also explain why it is rational for some investors to “chase the trend.” Other models are devoted to the informational role of trading volume. The insiders’ optimal dynamic trading strategy over different trading periods is derived in a strategic model setting.

Chapter 5 classifies different herding models. Rational herding in sequential decision making is either due to payoff externalities or information externalities. Herding may arise in settings where the predecessor’s action is a strong enough signal such that the agent disregards his own signal. Informational cascades might emerge if the predecessor’s action is only a noisy signal of his information. Herding can also arise in principal-agent models. The sequence in which agents make decisions can be either exogenous or endogenous.

Stock market crashes are explained in Section 6.1. In a setting with widely dispersed information, even relatively unimportant news can lead to large price swings and crashes. Stock market crashes can also occur because of liquidity problems, bursting bubbles, and sunspots. Traders might also herd in information acquisition if they care about the short-term price path as well as about the long-run fundamental value. Under these circum-

stances all traders will try to gather the same piece of information. Section 6.2 discusses investigative herding models that provide a deeper understanding of Keynes' comparison of the stock market with a beauty contest. Section 6.3 deals with short-termism induced by the stock market. The survey concludes with a brief summary of bank runs and its connection to financial crises.

Target Audience

There are three main audiences for whom this book is written:

(1) **Doctoral students** in finance and economics will find this book helpful in gaining access to this vast literature. It can be used as a supplementary reader in an advanced theoretical finance course which follows a standard asset pricing course. The book provides a useful framework and introduces the reader to the major models and results in the literature. Although the survey is closely linked to the original articles, it is not intended to be a substitute for them. While it does not provide detailed proofs, it does attempt to outline the important steps and highlight the key intuition. A consistent notation is used throughout the book to facilitate comparison between the different papers. The corresponding variable notations used in the original papers are listed in footnotes throughout the text to facilitate cross-reference.

(2) **Researchers** who are already familiar with the literature can use this book as a source of reference. By providing a structure for this body of literature, the survey can help the reader identify gaps and trigger future research.

(3) **Advanced undergraduate students** with solid microeconomic training can also use this survey as an introduction to the key models in the market microstructure literature. Readers who just want a feel for this literature should skim through Chapters 1 and 2 and focus on the intuitive aspects of Chapter 3. The dynamic models in Chapter 4 are more demanding, but are not essential for understanding the remainder of the survey. The discussion of herding models in Chapter 5 and stock market crashes and the Keynes' Beauty Contest analogy in Chapter 6 are accessible to a broad audience.

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Chapter 1

Information, Equilibrium Concepts and Efficiency Concepts

Financial markets are driven by news and information. The standard asset pricing theory assumes that all market participants possess the same information. However, in reality different traders hold different information. Some traders might know more than others about the same event or they might hold information related to different events. Even if all traders hear the same news in the form of a public announcement, they still might interpret it differently. Public announcements only rarely provide a direct statement of the value of the asset. Typically one has to make use of other information to figure out the impact of this news on the asset's value. Traders with different background information draw different conclusions. Financial markets cannot be well understood unless one also examines the asymmetries in the information dispersion and assimilation process.

In economies where information is dispersed among many market participants, prices have a dual role. They are both:

- an index of scarcity and
- a conveyor of information.

Hayek (1945) was one of the first to look at the price system as a mechanism for communicating information. This information affects traders' expectations about the uncertain value of an asset. There are different ways of modeling the formation of agents' expectations. Muth (1960, 1961) proposed a rational expectations framework which requires people's subjective beliefs about probability distributions to actually correspond to objective probability distributions. This rules out systematic forecast errors. The advantage of the rational expectations hypothesis over ad hoc formulations of expectations is that it provides a simple, general and plausible way of handling expectations. Agents draw

inferences from all available information derived from exogenous and endogenous data. In particular their infer information from publicly observable prices. In short, investors base their actions on the information conveyed by the price as well as on their private information.

Specific models which illustrate the relationship between information and price processes will be presented in Chapters 3 and 4. In Section 1.1 and 1.2 of this chapter we provide the basic conceptual background for modeling information and understanding the underlying equilibrium concepts. Section 1.3 highlights the difference between allocative efficiency and informational efficiency.

1.1 Modeling Information

If individuals are not fully informed, they cannot distinguish between different states of the world.

State Space

A state of the world ω fully describes every aspect of reality. A state space, denoted by Ω , is the collection of all possible states of the world ω . Let us assume that Ω has only finitely many elements.¹ A simplistic example illustrates the more abstract concepts below. Consider a situation where the only thing that matters is the dividend payment and the price of a certain stock. The dividend and the price can be either high or low and there is also the possibility that the firm goes bankrupt. In the latter case, price and dividend will be zero. A state of the world ω provides a full description of the world (in this case about the dividend payment d as well as the price of the stock p). There are five states $\omega_1 = \{d_{\text{high}}, p_{\text{high}}\}$, $\omega_2 = \{d_{\text{high}}, p_{\text{low}}\}$, $\omega_3 = \{d_{\text{low}}, p_{\text{high}}\}$, $\omega_4 = \{d_{\text{low}}, p_{\text{low}}\}$ and $\omega_5 = \{d = 0, p = 0\}$. An event E is a set of states. For example, the statement ‘the dividend payment is high’ refers to an event $E = \{\omega_1, \omega_2\}$. One can think that a state of nature is chosen e.g. by nature but the individual might not know which state is the true state of the world or even whether event E is true.

From Possibility Sets to Partitions

Information allows an individual to rule out certain states of the world. Depending on the true state of the world $\omega \in \Omega = \{\omega_1, \omega_2, \omega_3, \omega_4, \omega_5\}$ she might receive different information. If for example an individual learns in ω_1 that the dividend payment is high, she can eliminate the states ω_3 , ω_4 and ω_5 . In state ω_1 she thinks that only ω_1 , and ω_2 are possible. One way to represent this information is by means of possibility sets.

¹Occasionally we will indicate how the concepts generalize to an infinite state space Ω .