Universität Paderborn

Dissertation

The Role of Information in Decision-Making, Ideology Adoption, and Financial Markets with Bubbles

vorgelegt von

Carina Burs, Master of Science

geboren am 24. Januar 1994 in Salzkotten

zur Erlangung des akademischen Grades

Doktor der Wirtschaftswissenschaften

- Doctor rerum politicarum -

vorgelegt bei der

Fakultät für Wirtschaftswissenschaften

betreut durch

Prof. Dr. Thomas Gries (1. Gutachter)

Prof. Dr. Claus-Jochen Haake (2. Gutachter)

Paderborn, im April 2023

Abstract

This dissertation examines the role of information in individual decision-making, ideology adoption, and financial markets, including bubbles. Information is one of the most important factors in decision-making. While the neoclassical assumption of perfect information is an important conceptual benchmark, in reality, optimal decisions are decisions under imperfect information. Individuals have to find ways to collect and process information while they are confronted with large amounts of complex, ambiguous, or even false information. They have to find those options that best serve their preferences. How can information be acquired under imperfect information? Individuals can sequentially learn from acquired information about their individual match by updating their beliefs in a Bayesian fashion. This process reduces uncertainty, but can be time-consuming. How can decisions under imperfect information be made in a simple yet rational way? Heuristic rules can be used to quickly make a decision that is sufficient under given time and budget constraints. A second strategy for simple decision-making is to adhere to ideologies. Ideologies provide rules, norms, and values to follow. Individuals can use the information acquisition process to find those ideologies that best match their needs. Once chosen, they can substitute for information acquisition and act as heuristic reasoning. This examines the role of information at the individual level. The analysis is extended to aggregate market behavior by finally addressing the question: What are the effects of asymmetric information and heterogeneous beliefs on financial market behavior? Traders receive different information and form heterogeneous beliefs about asset prices. How information is disseminated and how traders react to it determines market behavior. For example, stable and unstable financial cycles occur. Abnormally high asset prices favor the emergence of bubbles that can deflate or burst. Monetary policy in this model can stabilize this market but cannot prevent bubbles.

Contents

1 Introduction

"The world you perceive is drastically simplified model of the real world."
- Herbert A. Simon, *Administrative Behavior* (1947)

Information is one of the most important components of decision-making. In early theoretical economic models, the "economic man" or "homo economicus" is assumed to always act rationally, maximizing subjective utility with perfect information. In reality, however, most decisions have to be made with imperfect information. Therefore, it is necessary to find ways to gather information and to process this information while finding a decision. During this information acquisition process, individuals are confronted with large amounts of complex, ambiguous, or even false information. They also face unpredictable events and circumstances, such as political instability, natural disasters, or financial crises. One way to overcome these obstacles is to learn from acquired information, which reduces uncertainty but can be costly and time-consuming. An alternative way of arriving at a decision is through the application of heuristics. Heuristic rules can be used to quickly make a decision that is sufficient under given time and budget constraints. Closely related to the idea of using heuristics as a "shortcut" is the adoption of ideologies, or more generally, belief systems. Ideologies define rules, norms, and values that individuals can rely on when making decisions and they can therefore be used as heuristics. However, the choice of particular ideologies is another decision under imperfect information, which is an example of the general information acquisition process. Moreover, the availability of information affects not only individual decisions but also aggregate market behavior. This can be analyzed using an arbitrary financial market as an example. Investors need information about asset prices to make investment deci-

sions. For example, asset prices may be abnormally high, which favors the emergence of financial bubbles. The way in which information about prices is disseminated influences individual beliefs, which determines long-term market behavior.

In this context, the following questions arise. (1) How can information be acquired under imperfect information? (2) How can decisions under imperfect information be made in a simple yet rational way? (3) What are the effects of asymmetric information and heterogeneous beliefs on financial market behavior? The following sections provide an overview of the literature on information in decision-making and in asset pricing, including bubbles. Furthermore, the objectives of this dissertation are presented.

1.1 Decision-making and Information Acquisition

There are three main mental ways of decision-making: logic, statistics, and heuristics. Usually, logic and statistics are associated with rational decision-making, while heuristics are associated with intuitive or even irrational thinking (Gigerenzer & Gaissmaier, 2011). This dissertation compares and combines statistical and heuristic strategies for rational decision-making from an individual point of view to answer the first two questions, namely: (1) How can information be acquired under imperfect information? And: (2) How can decisions under imperfect information be made in a simple yet rational way?

Over time, economic agents are confronted with an increasing number of options. To make a decision, information is needed. However, information is not available as a whole. Instead, an individual can collect pieces of information at different points in time and learn from that additional information. For example, suppose someone discovers a new gym and hears people talking about it. This person is interested in becoming a member. But how does he or she know if this facility meets his or her preferences? Based on these other people's opinions and the personal knowledge, prior beliefs about this gym can be formed. However, the person is unsure if this perception is true. As most gyms require memberships of several months or years, more information is needed to make a decision. The person may then hear about recent experiences from friends, who have visited that particular facility, or he or she may read reviews online. Thus, the person

learns from these additional sources of information and can use this information to update the prior beliefs. This reduces uncertainty and a more accurate decision can be made about becoming a member of this gym.

To understand the process of decision-making in-depth, we need an interdisciplinary approach. While the idea of the "economic man" who rationally maximizes utility dates back to the end of the 19th century, postwar economics extended this idea to Bayesian rationality, which means that subjective expected utility is maximized while beliefs are consistently updated by new information using Bayes' rule. Later research, which has become known as behavioral economics, has further challenged this view of the "economic man" and combines elements of economics and psychology to study the behavior of individuals or institutions and intents to understand why their economic decisions may deviate from the perfectly rational option.

In the economic literature, the analysis of the role of information starts with the seminal works of Stigler (1961, 1962), who develops one of the first models of information search. Earlier, Hayek (1945) already points out the importance of information heterogeneity in a society. Stigler (1961) examines the purchase of a homogeneous good. Information is represented only by the price of the product and the consumer has to decide how many search steps to conduct prior to the search. One search step means visiting a firm that offers the respective good, which reveals all information about the price. The product with the lowest price is chosen. Search costs are identified with time so that the cost is proportional to the number of search steps. McCall (1965) and Nelson (1970) criticize Stigler (1961) by suggesting that a sequential search process is more appropriate. The question is how much information the individual should acquire. This stopping problem has also been studied by Wald (1947) and Arrow et al. (1949). In the above setting, the consumers visit one firm at a time and compare the prices with a reservation price. They buy the product as soon as they find a firm that offers a price below this reservation price.

Before this was applied in economic models, mathematicians developed statistical theories for decision-making, such as Wald's (1947) sequential analysis for decision-making

under uncertainty. A key element of his sequential modeling is experimentation. A decision-maker has to choose an "experiment" to obtain information and then decide whether to continue experimenting, i.e., acquiring information, or to take a final action. Another example is the theory of dynamic programming by Bellman (1957). In this approach, a value function of discounted expectations is maximized by recursively solving simpler sub-problems. This value function obeys the Bellman-equation, which consists of the currently expected utility plus a discounted value of additional information. In his model of job search, McCall (1970) is one of the first to introduce these theories into the economics literature.

Nelson (1970) extends Stigler's model by adding product quality as relevant information for a consumer's purchase decision since "[i]nformation about quality differs from information about price because the former is usually more expensive to buy than the latter" (Nelson, 1970, p. 311).[1] Today, individuals are confronted with an increasing number of alternatives in a choice set. Each alternative is characterized by its own attributes. However, as known from the "market for lemons", products can have many attributes that are not immediately observable, but which are important for making a decision (Akerlof, 1970). Therefore, decision-makers collect information about these differentiated attributes that have to meet the consumer's preferences. Thus, in this dissertation, consumers search for their individual match with the products they consider for purchase. The purpose of information acquisition is to reveal this match value, which is unknown in a setting of imperfect information. The simplest modeling of goods with differentiated attributes comes from spatial and distance models of differentiated products (Lancaster, 1966). An example application of searching for a match is job search models (Jovanovic, 1979). In this dissertation, the match value is defined using the Minkowksi distance between the product characteristics and individual preferences. In the gym example, individuals collect information about their personal match with the

[1] Therefore, he distinguishes between two kinds of products: *search goods* and *experience goods*. Products are called search goods when most of their attributes are known before purchase. In contrast, experience goods are products whose majority of attributes are only revealed after purchase. This distinction becomes blurred with technological progress and new sources of information (Klein, 1998). Therefore, these categories are not used in this dissertation.

gym's services. For example, the match value is increased if group fitness classes are preferred and the facility offers such classes.

Even when information is collected, there may be pieces of information that are incomplete or even incorrect. For example, friends may tell something they heard from someone else and that information may be modified each time a person shares it. Furthermore, the individual match value with a particular gym cannot be revealed after one visit because each visit is different, e.g., a fitness instructor is in a different shape on different days. Thus, an individual's information set remains incomplete and the information received contains uncertainty. As more information is collected, the level of uncertainty decreases, but the amount of information collected is restricted by search costs. A standard framework for modeling such an individual's learning process before making a decision under uncertainty is the Bayesian framework (DeGroot, 1970). It is known as Bayesian updating, Bayesian learning, or Bayesian inference and works as follows. Suppose there is an unobservable variable θ that is needed by the individual to make a decision. Initially, the agent is assumed to form prior beliefs about θ and the joint distribution of θ and the signals. Over time, an agent receives signals about θ that are used to update the posterior beliefs according to Bayes' rule. Each signal, or each piece of information, reduces the prior uncertainty. Thus, with more information, initial beliefs can either be reinforced or changed.

This framework has been used in various contexts in the literature. For example, based on the model of Jensen (1982), McCardle (1985) uses Bayesian learning for gathering information about the profitability of innovative technologies. At each step, the individual must decide whether to continue information acquisition, adopt the technology, or reject it. This is a sequential search, and dynamic programming is used for an optimal stopping rule. Chatterjee and Eliashberg (1990) use a micromodeling approach to study the adoption at the individual level. Ulu and Smith (2009) extend these models including general probability distributions for the profitability of technologies and general signal processes. More recently, Zhong (2022) considers decision-makers who can choose the signal process as a source of information. Wald's idea of experimentation in information

acquisition has been extended by Moscarini and Smith (2001) with the choice of the signal precision. Che and Mierendorff (2019) include the choice of different information sources. In a marketing context, Bayesian learning was first applied by Roberts and Urban (1988) to a consumer brand choice problem. This model is further developed by Erdem and Keane (1996). In their model, consumers learn about the quality of a product both by active learning through use experience and by passive learning through exogenous advertising signals. This is applied in many areas, such as learning about the effectiveness of pharmaceutical drugs (Crawford & Shum, 2005), the matching of tariff plans (Goettler & Clay, 2011), or the quality of insurances (Israel, 2005). These papers focus on the learning procedure for specific products with particular characteristics.

In this dissertation, Bayesian learning is used in an expected utility maximization problem. Individuals learn sequentially about their unknown subjective match with the items under consideration. The match value and the signals are assumed to be normally distributed, which is in line with Erdem and Keane (1996).[2] Expected utility is assumed to be exponential because it depends positively on the match and negatively on uncertainty. The individuals' decision problem is not only a choice problem, but also an optimal stopping problem. After receiving a piece of information and updating their current beliefs, they have to decide whether another piece of information increases their expected utility or not. Thus, they have to anticipate the expected utility after another step of information acquisition without conducting it. This process stops as soon as no further increase in utility is anticipated. At this point, this model is closer to McCardle (1985). Erdem and Keane (1996) consider only the choice of one particular product. Updating beliefs about the true match value can mean that the expected match value decreases with further information, which may also decrease expected utility. In this dissertation, however, more information is assumed to increase expected utility. The benefit of more information is the reduction in uncertainty. This can be ensured by sufficient risk aversion. Thus, the first novelty in this model is the relationship between risk aversion and search. The more risk-averse individuals are, the more their utility is

[2] For example, McCardle (1985) use a Beta prior distribution and Bernoulli signals. Che and Mierendorff (2019) and Zhong (2022) use Poisson signals.

reduced by uncertainty. More information reduces uncertainty. Thus, risk aversion is the motivating force for information acquisition.

The second novelty of this approach is that the solution contains not only an optimal stopping time and a choice of alternatives, but also the allocation or a mixture of several alternatives. Under perfect information, the product with the highest match value is chosen. However, when information is incomplete and the search is costly, the optimal choice must be made under imperfect information. This can lead to an ex ante choice of a mixture of several products, or even to a choice that does not include the product with the highest true match value if the initial signals are very low. Individuals then try more products because they cannot be sure which one is the best.

As long as the individual continues to buy an alternative, the learning process continues through experience. The idea of two types of information, namely experience and advertising, is also used simultaneously by Erdem and Keane (1996). In this dissertation, experience forms a second stage in the information acquisition process that can lead to adjustments in the decisions that are made prior to the purchase. The expected match value may even converge to the true match value as the experience continues. If a product is not purchased, learning about the match stops and the true match value cannot be approached.

However, this process of information acquisition is time-consuming and this means high search costs. Therefore, alternative ways of finding a decision are discussed that address the second question of how to make decisions in a simple yet rational way. One of the most famous opponents of the "economic man" abstraction in decision-making is Herbert A. Simon who developed the well-known theories of *bounded rationality* and *satisficing* (Simon, 1955). Bounded rationality means that rationality is cognitively limited by the computational capacity of the human mind and the environment in which the human mind operates. According to Simon (1956), decision-makers do not, in general, maximize but they "satisfice". This means that individuals define a decision criterion, called an "aspiration level", and as soon as they find an option that meets or exceeds this criterion, they choose that option. In this case, not every available alternative is considered and

not all available information is collected. Thus, satisficing means finding an option that is good enough but may not be the best option. In the gym example, consider a person who follows a very strict workout schedule. If this person has to find a new gym, for example because of a new job or because the current gym closes, the workout plan cannot be interrupted for an extended period of time. Therefore, this person chooses the first gym that meets the requirements for continuing the workout plan and therefore satisfies his or her preferences, even though there may be better alternatives.

Despite developing the theory of bounded rationality, Simon emphasized that individual behavior in decision-making needs to be investigated empirically rather than explained only by formal statistical models (e.g., see Simon, 1997). This encouraged behavioral economists and psychologists to test whether rational theories are being applied and they found large deviations. For example, Tversky and Kahneman (1973, 1974) find such deviations in various experiments.

To get around the above limitations, Simon suggests the use of heuristics in economic decision-making instead of strict optimization methods (Simon, 1990; Simon & Newell, 1971). Heuristics are mental shortcuts that can be used to reduce complexity and make decisions quickly with only a few pieces of information. Heuristics are "rules-of-thumb" that can be used to avoid complex calculations while still finding good enough solutions. Thus, satisficing is a type of heuristic, but there are many more heuristic rules. This has become a key element of behavioral economics. Many empirical studies find evidence for the use of heuristics instead of detailed information acquisition (Benartzi & Thaler, 2001; Friedrichs, 2002; Hauser, 2011; Payne et al., 1993).

There are two approaches to heuristics in the literature that can be associated with Tversky and Kahneman's *heuristics and biases* program and Gigerenzer's *fast and frugal heuristics* program. The heuristics and biases approach examines judgment under uncertainty. Tversky and Kahneman (1974) argue that judgments rely on a limited number of heuristic rules to simplify the complex calculations of probabilities. They point out, that heuristics are "useful, but sometimes they lead to severe and systematic errors" (Tversky & Kahneman, 1974, p. 1124). They see intuitive judgment not as a simplification of

rational models, but as different in kind. Deviations from the normative rational theory are called biases and determine the heuristics (Gilovich et al., 2002). This is the starting point for Gigerenzer's (1991) critique of this heuristics and biases program. He argues that the errors which "one wants to explain by heuristics are in fact not errors" (Gigerenzer, 1991, p. 16).

Gerd Gigerenzer is the director of the Center for Adaptive Behavior and Cognition (ABC), a research group that developed the fast and frugal heuristics program (Gigerenzer et al., 1999). This program treats heuristics as algorithmic models of decision-making consisting of three parts: (i) a search rule, (ii) a stopping rule, and (iii) a decision rule. For example, using the satisficing heuristic means searching for alternatives in any order, stopping when the first alternative meets or exceeds the aspiration level, and choosing that alternative (Gigerenzer & Gaissmaier, 2011). The ABC research group suggests replacing the picture of an all-knowing mind with that of a bounded mind using an *adaptive toolbox* full of fast and frugal heuristics (Gigerenzer & Todd, 1999). Examples include the *recognition heuristic* (Goldstein & Gigerenzer, 2002) and the *take-the-best heuristic* (Gigerenzer & Goldstein, 1996). The recognition heuristic exploits the lack of knowledge. "If one of two objects is recognized and the other is not, then infer that the recognized object has the higher value with respect to the criterion" (Goldstein & Gigerenzer, 2002, p. 76). The take-the-best heuristic is a satisficing algorithm that finds a decision based on cues that are ordered by cue validity. The search stops as soon as one cue discriminates. That is, it has a better cue value than another. A famous example application of these heuristics is estimating the population sizes of cities.

As mentioned above, bounded rationality also includes the idea that heuristics must be adapted to the environment in which they are used in order to perform well.[3] Gigerenzer and Todd (1999) use the term *ecological rationality* to define that a "heuristic is ecologically rational to the degree that it is adapted to the structure of an environment" (Gigerenzer & Todd, 1999, p. 13). Thus, heuristics should not be considered irrational per se, but the context in which they are applied is important. Therefore, this disserta-

[3]Simon (1956) was not the first to stress the importance of the properties of the environment in which rational decisions are made (e.g., Brunswik, 1943).

tion incorporates heuristic rules into a model of information acquisition and introduces conditions under which it is rational for an individual to follow a heuristic instead of engaging in a costly information acquisition process. This heuristic is not specified. Different heuristics from the adaptive toolbox could be applied to our model. For a better understanding, a simple heuristic is chosen. It is a social heuristic approach. Instead of acquiring (costly) information by themselves, individuals can rely on the experiences and opinions of their social environment without costs. In the gym example, this social heuristic is applied when only the opinions of friends and family are considered to make a decision, without acquiring further information about how well the facility's services match personal preferences.

In addition to general heuristic rules, this dissertation proposes another "tool" to facilitate the decision-making process. This is the concept of ideologies, or more generally, belief systems. But what is an ideology? Ideologies are often associated with political conflict, where they are used as instruments to mobilize individuals who identify with a group to reach a particular goal (Gutiérrez Sanín & Wood, 2014; Seliger, 1979). In this case, the word ideology has a rather negative connotation, but there are broader definitions of the term. For example, according to Campbell (1960), ideology is a "structure of attitudes. By origin and usage its connotations are primarily political, although the scope of the structure is such that we expect an ideology to encompass content outside the political order as narrowly defined - social and economic relationships, and even matters of religion, education, and the like" (Campbell, 1960, p. 192). Walsby (1947) defines ideology as "the complete system of cognitive assumptions and affective identifications which manifest themselves in, or underlie, the thought, speech, aims, interests, ideals, ethical standards, actions – in short, in the behaviour – of an individual human being" (Walsby, 1947, p. 145). Moreover, there is a more economic view of ideologies as part of rational decision-making under uncertainty (Denzau & North, 2000). Belief systems can be described as "implicit, non-formal institutions" (Khalil, 2011, p. 642) that serve as guidance in situations with imperfect information. From a cognitive perspective, they generate meaning in life. Thus, ideologies can be understood as meaning systems that

are provided by a culture or society (MacKenzie & Baumeister, 2014). Individuals do not create their own systems of meaning. Instead, they choose existing frameworks, i.e., ideologies, which are systems of values and beliefs that help them process information and make decisions.

Why is it necessary to include ideologies in decision-making? Under conditions of imperfect information, individuals seek guidance in processing information. Ideologies provide such guidance, helping understand social reality, identify with a group, and solve everyday life problems. Furthermore, ideologies provide interpretations of the world and how it should be (Jost et al., 2009). Therefore, individuals do not choose ideologies at random. On the one hand, belief systems serve individuals' needs, values, and preferences which enhance subjective expected utility. On the other hand, the social environment offers ideologies that reconcile these needs and preferences. Gries et al. (2022) describe this as the "market for ideology" (Gries et al., 2022, p. 66) and develop a formal model of individual ideological matching. Each individual strives to satisfy a variety of psychological human needs or, in other words, mental preferences, which include, for example, safety, order, belongingness, and self-esteem (see Gries and Müller (2020) for a detailed categorization). The extent to which each need is desired to be fulfilled is individual, as is the extent to which a belief system serves each need. This determines the match and the choice of an ideology can be formalized in a rational choice model.

Individuals have to find those ideologies that best resonate with their subjective need systems. Gries et al. (2022) argue that individuals "engage in a process of trial-and-error that leads them, over time, to converge on a particular belief system that is on offer in their informational environment." (Gries et al., 2022, p. 69). This is a very vague description of the decision-making process. Trial means gathering information that can be learned from. Therefore, in this thesis, the Bayesian learning framework is used to model the process of finding those ideologies that best meet the individual's needs and preferences. Since a given culture can provide a variety of ideologies (MacKenzie & Baumeister, 2014), individuals do not necessarily choose only one ideology. Instead, they choose a mixture of ideologies that best match their specific needs (Kay & Eibach, 2012).

The Bayesian learning framework allows for the adoption of a mixture of ideologies just as it is used to find an optimal product allocation.

In addition to finding matching ideologies, there is a second aspect of their use that is addressed by the model in this doctoral thesis. Once chosen, ideologies can be used to guide everyday decision-making. As argued above, ideologies can be used to reduce complexity and make decisions. They provide rules, norms, and values that individuals can rely on, which creates consistency, certainty, and meaning in life. Therefore, following the rules, norms, and values of the chosen ideologies serves the individual's needs and increases utility. These rules can be applied at low cost and in this way ideologies function as heuristics. They provide guidance for information processing and decision-making. The formal model shows how belief systems are involved in everyday decision-making. Utility is derived not only from pure consumption, but also from the satisfaction of psychological needs and preferences. Therefore, consumers are willing to pay more for a good if it not only satisfies their material needs, but also their ideological needs. In the example of choosing a gym, consider a woman who adopts an ideology that strictly separates the roles of men and women. She follows the ideological rule, that she can only be a member of women-only gyms, even if they are more expensive or offer fewer services than other gyms.

1.2 Information in Asset Pricing and Financial Bubbles

In the Bayesian learning framework, different individuals may not end up with the same posterior beliefs because they may differ in their prior beliefs or they may receive different signals, i.e., they form heterogeneous beliefs or they receive asymmetric information. So far, the role of information in individual decision-making has been analyzed. This analysis is extended to aggregate market behavior by addressing the third question: What are the effects of asymmetric information and heterogeneous beliefs on financial market behavior?

Why does information play an important role in financial markets? Investors are concerned with perceptions of price movements. As in traditional economic models, standard financial theory assumes perfect information. In reality, however, traders have different

information and receive different news. In addition, they interpret information differently. Therefore, agents trade assets based on subjective information. A rising price of an asset may be due to some investors receiving good news, which increases the demand for this asset. This information is used to make a decision about an individual's actions. They may change their current portfolio depending on their subjective expectations of future price movements. Thus, information influences investors' actions and asset prices. At the same time, price movements and actions provide information to other traders. For example, Grossman and Stiglitz (1980) and Verrecchia (1982) model information acquisition decisions about asset prices. This dissertation studies the impact of information at the aggregate level. It considers the diffusion of information across a group of investors and the dynamics of their beliefs about asset prices.

Throughout history there have been several huge increases in asset prices, sometimes followed by sharp declines. Such anomalous price patterns can lead to misallocation of resources in the real economy and even trigger financial crises (Bordo et al., 2002). These, in turn, have serious consequences for the economy, such as negative effects on output, employment, debt, and trade (Benguria and Taylor, 2020; Jordà et al., 2013; Reinhart and Rogoff, 2009). The empirical literature therefore attempts to detect and forecast these patterns. Recent work finds cyclical behavior in credit, the credit to GDP ratio, house prices, and equity prices, which are key indicators of the financial cycle (e.g., Drehmann et al., 2012; Galati et al., 2016; Strohsal et al., 2019). However, it is also important to understand how these price patterns emerge.

Large increases in asset prices are often explained by financial bubbles. Famous historical examples include the *Dutch Tulip Mania* (1634-1637), the *South Sea Bubble* (1720), and the *Mississippi Bubble* (1719-1720). More recent examples are the *Dot-com Bubble* (1990s-2002) and the *U.S. Housing Bubble* (1996-2006). Kindleberger and Aliber (2005) provide a detailed summary of the history of bubbles. Defining a bubble is ambiguous. According to Kindleberger and Aliber (2005), a bubble is "an upward price movement over an extended period of fifteen to forty months that then implodes" (Kindleberger & Aliber, 2005, p. 25). This definition is inherently imprecise. It does not specify how

much the asset price has to rise to be a bubble. Furthermore, large price movements can naturally occur due to alterations in supply and demand. A more precise definition, accepted by most economists, defines a bubble as a deviation of an asset price from its fundamental value. Brunnermeier (2008) states that "[b]ubbles refer to asset prices that exceed an asset's fundamental value because current owners believe they can resell the asset at an even higher price" (Brunnermeier, 2008, p. 1). He divides the literature on bubbles into four categories. In the first two categories, investors have rational expectations, but symmetric or asymmetric information. In the third category, rational investors interact with behavioral investors and in the fourth category, they hold heterogeneous beliefs. Thus, information plays an important role in the formation of bubbles. Standard bubble models are rational bubble models and analyze especially the existence and rise of bubbles (e.g., Allen et al., 1993; Blanchard and Watson, 1982; Tirole, 1982). Later research loosens the assumption of perfect rationality and focuses on the conditions for their emergence and bursting (e.g., Abreu and Brunnermeier, 2003; Scheinkman and Xiong, 2003). However, not every mispricing of asset prices is caused by a bubble. Instead, prices move in cycles of varying lengths and heights (Fritz et al., 2022; Galati et al., 2016; Hiebert et al., 2015; Strohsal et al., 2019). Large asset price drops or market crashes can be caused not only by bursting bubbles but also by asymmetric information. In Gennotte and Leland (1990), small changes in information can lead to huge price declines and cause a market crash. Romer (1992) shows that heterogeneous information quality and uncertainty about the signal quality of other traders can lead to price movements and crashes.

This dissertation examines general financial market behavior and derives conditions for the occurrence of various dynamics. Nevertheless, the emergence of bubbles and their deflation or bursting is included in the model. It departs from the ideas of the model of Abreu and Brunnermeier (2003), who analyze the role of information in the synchronization problem of rational arbitrageurs during a bubble period. A bubble emerges at a random point in time and agents learn sequentially that a bubble exists. This reflects information asymmetry. However, the individual does not know whether others know

about the bubble and whether it is profitable to ride the bubble. Traders know that a market collapse will follow, but they hope for high returns if the bubble continues to grow. This results in the bubble persisting for a period of time. However, the investors try to exit the market before it crashes. The bubble finally bursts when a sufficient number of traders exit the market or after an exogenous time.

There are two key elements of Abreu and Brunnermeier (2003) that are adopted in this dissertation. First, there are two groups of traders with different information. In the model of Abreu and Brunnermeier (2003), arbitrageurs learn sequentially that there is a bubble that eventually bursts. Thus, there is one group that knows that a bubble exists while the other group does not. In this dissertation, there is one group of traders who currently believe that asset prices are overvalued, while the other group does not. This leads to a differential equation for the first dynamic variable: the number of traders who currently believe that asset prices are abnormally high. It depends on this number itself and on the rate of asset growth, which is the second dynamic variable in this model. The result is a two-dimensional system of differential equations that describes various movements in the financial market. Individuals can change their beliefs depending on the asset growth rate and the number of agents who believe in overpricing. This is modeled as an information diffusion process with logistic growth in an SIS-model. The SIS-model is an epidemiological model that describes the outbreak of a disease without immunization. Susceptible individuals can be infected and return to the susceptible group after cured. This ensures that individuals can start believing that asset prices are abnormally high and also stop believing it. It is in line with Shiller's (2014) idea that bubbles are a "social epidemic" in which investors spread information about price increases enthusiastically from person to person.

The second element adopted from Abreu and Brunnermeier (2003) is the idea of trying to increase returns by riding the bubble.[4] Even if investors know that a bubble exists - or, in this model, believe in overpricing - they stay in the market and try to profit from rising asset prices. Empirical evidence for this behavior is found by Brunnermeier

[4]This idea was included in earlier work, e.g., DeLong et al. (1990).

and Nagel (2004) or Temin and Voth (2004). Whether individuals behave in this way depends on how they respond to information about asset prices. This leads to different scenarios in the market. The dynamics of the asset price are modeled using the Capital Asset Pricing Model and additional savings. These additional savings also depend on the growth rate and the number of investors who believe in overpricing. In particular, the behavior of the market depends on the relationship between savings and the number of investors who perceive overpricing. The reason for this relationship can be explained by several phenomena of behavioral finance. The first reason is *herding*. This means that investors imitate the actions of others or base their decisions on the behavior of others. For example, in Avery and Zemsky (1998) agents show herding behavior by trading based on past trends even though this contradicts their initial information about the value of the asset. Evidence for individual herding behavior is found by Ashiya and Doi (2001), Graham (1999), and Welch (2000). A similar reason, which is also an explanation for herding, is the idea of *information cascades*, which means that investors follow the behavior of others without considering their own information (Bikhchandani et al., 1992). These phenomena imply that individuals believe that others have more information than they do. The opposite phenomenon is *overconfidence*. This refers to the phenomenon that some investors overestimate their private information relative to public information (Daniel et al., 1998; Hong et al., 2006; Scheinkman & Xiong, 2003). These phenomena can lead to both a positive and a negative relationship between additional savings and the number of investors who currently believe in overpricing.

Thus, these different responses to information about the beliefs of others determine market behavior. A phase plane analysis finds both stable and unstable equilibria. If agents increase their additional investment when they perceive that more others believe in overpricing, the market can behave cyclically. These cycles can occur after exogenous shocks, or they can be endogenously generated, which can be shown using the Poincaré-Bendixson Theorem. This is called the *euphoric scenario*. In contrast, if agents reduce additional invested savings when more others believe in overpricing, more stable equilibria occur. This is called the *cautious scenario*. Furthermore, in these scenarios, bubbles can

cyclically arise and deflate or they rise until they burst.

Returning to the bubble categorization of Brunnermeier (2008), two concepts are adopted in this thesis: asymmetric information and heterogeneous beliefs. Bubbles occur when everyone knows that prices are overvalued, but does not know that others know this as well. Bubbles under asymmetric information refer to the case where agents have the same prior distribution, but different information. Bubbles under heterogeneous beliefs occur when investors have different prior distributions but can receive the same information.[5] Both of these causes can lead individuals to believe that asset prices are abnormally high. Therefore, the Bayesian learning framework can be reapplied and works as a background mechanism in this model.[6]

Since large fluctuations in asset prices - and thus bubbles - can harm the economy, there is a debate in the literature about the question of whether central banks should intervene to prevent bubbles (Bernanke & Gertler, 1999; Cecchetti et al., 2000; Hördahl & Packer, 2006). Scherbina and Schlusche (2013) summarize several reasons against central bank intervention. For example, identifying a bubble is a difficult task because price increases can be caused by increases in fundamentals and not necessarily by a bubble. Moreover, pricking a bubble harms those who are holding the bubble assets. For example, Bernanke and Gertler (1999) argue that central banks should only respond to changes in expected inflation by increasing the interest rate. In their model, this policy stabilizes the economy and reduces bubbles. Therefore, in this dissertation, central bank intervention is studied by increasing the interest rate. This influences market behavior. For example, cyclical patterns are prevented and the market is stabilized. However, this policy does not prevent bubbles from emerging and bursting.

All this said, this dissertation aims to formally model and analyze the role of information in decision-making, ideology adoption, and financial market behavior, including bubbles. In summary, it contributes to the literature in the following ways. The Bayesian

[5] The study of bubbles and crises under heterogeneous beliefs began with Harrison and Kreps (1978). For a review see Xiong (2013).

[6] Models that explicitly use Bayesian learning in the context of asset prices and bubbles can be found in Morris (1996) and Werner (2018).

learning framework is revised to emphasize information acquisition as a risk-reducing tool for risk-averse consumers, in order to compare the result with the benchmark scenario under perfect information and to heuristic rules. While there is a large literature analyzing existing heuristic rules, formal models of when they are applied are still rare. This dissertation contributes to the literature on this topic in two ways. First, it develops a general model of decision-making under uncertainty that shows when it is rational to choose a heuristic rule instead of acquiring information. Second, a model is introduced that explains how ideologies can be used as heuristics and how these ideologies, or heuristics, are chosen. As mentioned above, there is a large body of empirical work that identifies cyclical movements in financial markets. To the best of my knowledge, there is no theoretical model which explains these movements by taking into account behavioral elements with the role of information and heterogeneous beliefs.[7]

1.3 Summary of this Thesis

This dissertation consists of three self-contained contributions to the literature on economic decision-making, behavioral economics, and finance. Each contribution can stand well on its own, but they are linked by the implications of information.

All papers present formal analytical models to answer the research questions. The papers in chapter 2 and chapter 3 are closely related from a theoretical point of view. Both explicitly use the framework of Bayesian learning to model the acquisition of information about individual match values. They model a sequential information acquisition process using a standard expected utility maximization approach. The third paper, presented in chapter 4, uses different theoretical methods. A phase plane analysis of a two-dimensional system of differential equations is conducted to study the long-term behavior of a financial market. In this way, both stable and unstable equilibria, including spirals, are detected and even limit cycles are found by applying the Poincaré-Bendixson Theorem. However, Bayesian learning serves as a basis for explaining changing beliefs about asset prices.

[7] Sorger (2018) conducts a phase plane analysis of a two-dimensional system of differential equations to model bubbles and cycles in the Solow-Swan model, but this does not include behavioral elements.

The first paper, entitled *Decision-making under Imperfect Information with Bayesian Learning or Heuristic rules*, which is presented in chapter 2, is a joint work with Thomas Gries. It is an adapted version of a paper that is published in the Center for International Economics (CIE) Working Paper series. This contribution introduces the process of information acquisition for decision-making in a general sense. It develops a formal model of decision-making with Bayesian learning or with heuristics and compares this choice under imperfect information with the benchmark choice under perfect information. To be precise, a simple consumer decision for the allocation of differentiated goods is studied in an expected utility maximization problem. The solution consists of the optimal number of information acquisition steps as well as the optimal product quantities and can be found sequentially. A key feature of this model is that information is a risk-reducing instrument in the expected utility function of a risk-averse decision-maker. It is shown that more risk-averse individuals acquire more information before making a decision. Thus, information not only reveals the properties of the products under consideration, but also reduces the risk that the subjective perception of these products is wrong. Moreover, sufficient conditions are developed that show when a lower signal precision leads to more information acquisition steps. The model proposes two ways in which information can be collected. In addition to a costly sequential search process of information acquisition and updating the current perception in a Bayesian manner, a simple strategy using heuristic rules is presented. For a better understanding, a social heuristic is chosen, which takes into account the opinions of the individual's social environment. However, other heuristic rules would also be appropriate. The model shows when it is rational to follow a heuristic approach instead of going through a costly information acquisition process. Both of these strategies are compared to the choice under perfect information. In the latter case, mainly a single product is chosen, whereas under imperfect information, a mixture of more products is purchased. Once a product is chosen - either after acquiring information using Bayesian learning or by applying heuristic rules - learning about that item continues through experience after the purchase. As long as a product is consumed, the expected match value approaches the true match value. If a product is not purchased,

the true match value remains unknown.

The second paper, which is called *The Choice of Ideology and Everyday Decisions*, and which constitutes chapter 3, is a joint work with Thomas Gries and Veronika Müller. It is a revised version of a working paper that is published in APSA preprints, a pre-publication platform of the American Political Science Association. In this contribution, the Bayesian learning approach of information acquisition from the first paper is used to find ideologies that meet individual's needs and preferences. Thus, this paper shows how individuals search for ideologies, or belief systems in general, and identify those that best suit them. Based on the model of an ideological match by Gries et al. (2022), they collect information about this quantity. The starting point for this learning process is the individual's social environment, such as the family. With further information, this idea of a match can be updated in a Bayesian manner. Individuals do not necessarily have to choose one particular ideology and apply only the rules of that single ideology. Instead, they can choose a mixture of ideologies and follow the norms of the belief system that are appropriate in a given situation. Once one or more ideologies are chosen, the individual will rely on the respective rules, norms, and values to process information and make decisions. This leads to the second contribution of this paper. It also contains a formal model of how ideologies determine everyday decision-making. Ideologies and their rules and norms can be used as heuristics to make decisions at low cost. They are chosen according to their needs and preferences. Since utility is determined not only by consumption preferences but also by psychological needs, decisions based on the rules and norms of ideologies increase utility.

The third paper, entitled *A Model of Cycles and Bubbles under Heterogeneous Beliefs in Financial Markets* and introduced in chapter 4, is a single-author paper that is published in the CIE Working Paper series and addresses a more specific topic where information also plays an important role. It analyzes the impact of asymmetric information and heterogeneous beliefs about asset prices on the long-term behavior of financial markets. The Bayesian learning framework of the first paper is not explicitly incorporated, but it serves as a background principle to explain the formation of heterogeneous beliefs.

Following the ideas of Abreu and Brunnermeier (2003), a financial market with two groups of traders is considered. One group believes that asset prices are abnormally high, while the other group does not. These beliefs can change as agents learn from new information, just as in the other papers. The dynamics of beliefs depends on the number of agents with the same beliefs and the growth rate of assets. The dynamics of the growth rate also depends on the number of agents, who currently believe that asset prices are overvalued, and the growth rate itself using the Capital Asset Pricing Model and additional savings that can be invested. This results in a system of two differential equations, which are analyzed in the phase plane. Moreover, the additional savings also depend on these two dynamic variables. How they are affected by the number of agents, who are believing in overpricing, can be explained by behavioral finance phenomena, such as herding or overconfidence. This leads to two scenarios - a euphoric scenario and a cautious scenario - depending on the relationship between additional savings and the number of agents who believe in overpricing. The financial market under consideration contains both stable and unstable equilibria. These equilibria can be spiraling or even approaching limit cycles. The model shows cyclical movements both exogenously and endogenously when agents are euphoric and try to ride possible bubbles. In the cautious case, there are more stable equilibria than in the euphoric case. Furthermore, the emergence of financial bubbles is examined by introducing an exogenous "bubble threshold" to indicate when asset prices contain bubbles. In both scenarios, the system can move outside the region of attraction of stable equilibria and the bubble grows until it bursts. If cycles occur in the euphoric scenario and the bubble threshold is sufficiently low, bubbles can emerge and deflate. In addition, the effect of monetary policy is studied by increasing the interest rate. This can directly stabilize the market and stop the cyclical movement, but it cannot prevent the formation and bursting of bubbles.

Finally, chapter 5, *Concluding Remarks*, outlines and discusses the general findings and implications of this dissertation and provides future research directions.

2 Concluding Remarks

This dissertation examines the role of information in general individual decision-making as well as at the aggregate level using a financial market as an example. In doing so, three questions are answered: (1) How can information be acquired under imperfect information? (2) How can decisions under imperfect information be made in a simple yet rational way? (3) What are the effects of asymmetric information and heterogeneous beliefs on financial market behavior? Thus, this dissertation sheds further light on the implications of imperfect information and on how optimal decisions can still be made from an individual's point of view.

The first question is answered by developing an information acquisition process using Bayesian learning. In chapter 2, *Decision-making under Imperfect Information with Bayesian Learning or Heuristic rules*, this process is introduced in a simple consumer decision for the allocation of differentiated goods. Individuals make a decision according to how well the characteristics of the products under consideration match their subjective preferences. This match is represented by an individual match value. While this match value is known in a world of perfect information, under imperfect information consumers can learn about it by updating their beliefs in a Bayesian manner. In this way, the utility maximization problem can be solved sequentially, obtaining an optimal number of information acquisition steps and an optimal product allocation. Collecting information not only brings the individual closer to the true match value, but also reduces the risk of misperceiving match. The key element of this process is that it is motivated by risk aversion. More risk-averse consumers collect more information before making a decision. As long as a product is consumed, more information is gained through experience and

the expected match value approaches the true match value. If a product is not chosen for purchase, the true match value is never revealed, even if the selection of that product would have been the choice under perfect information. In chapter 3, *The Choice of Ideology and Everyday Decisions*, this process of information acquisition is applied to the adoption of ideologies. Individuals have to find those ideologies that best resonate with and are consistent with their mental needs and preferences. Each individual is attracted to different ideologies. This can also be measured by a subjective ideological match value. Using the sequential maximization problem with Bayesian learning from above, individuals find their optimal mixture of ideologies to adopt. This extends the work of Gries et al. (2022), who focus on the modeling of the ideological match but only describe the information acquisition as a trial-and-error process.

Since this information acquisition process is time-consuming and thus costly, the second question above arises: How can decisions under imperfect information be made in a simple yet rational way? The answer is twofold. As a first alternative strategy, the application of heuristic rules is included in the model in chapter 2. More precisely, a social heuristic is proposed that takes into account the opinions of the decision-maker's social environment. However, other heuristic strategies can also be applied. By comparing the anticipated utility of information acquisition and the expected utility from using the heuristic, the consumer can decide either to go through the costly information acquisition process described above or to apply a simple heuristic. The latter is assumed to be costless. This provides a theoretical condition under which the use of heuristic rules is a superior and thus rational strategy for the consumers. After the purchase, they again learn by experience, just as they do after the costly information acquisition process.

A second alternative for finding a decision is included in chapter 3. Ideologies, or more generally belief systems, help to process and evaluate information. They substitute and/or complement information. Once they are chosen, ideologies can be used in everyday decision-making. They reduce complexity and can be applied to make decisions at low cost. In this way, ideologies function as heuristics. In order to arrive at a decision, individuals follow the rules, norms, and values that are predetermined by one or more

ideologies. This enhances utility, as the consistency with the chosen belief systems resonates with subjective needs and preferences. Thus, utility is derived not only from pure consumption, but also from following ideological rules and norms. This explains why vegans are willing to pay a higher price for vegan meals. Not only does it satisfy their need for food, but it is also consistent with their ideological rules of veganism, which provides additional utility.

Thus, this dissertation contributes to the literature on heuristics in two ways. While there are various models that describe heuristic strategies, formal models that include conditions for their applications are still rare (Gigerenzer & Gaissmaier, 2011). Chapter 2 shows when it is optimal to follow a heuristic, and chapter 3 shows how belief systems, i.e. certain heuristics, are chosen and rationally applied in everyday decision-making from an individual point of view.

The third question about the effects of asymmetric information and heterogeneous beliefs on financial market behavior is answered in chapter 4, *A Model of Cycles and Bubbles under Heterogeneous Beliefs in Financial Markets*, by studying the long-term behavior of financial markets in a phase plane analysis. The setting is divided into two scenarios - a euphoric scenario and a cautious scenario - depending on how investors respond to information about the beliefs of other traders. Both scenarios contain both stable and unstable equilibria. If agents are euphoric and increase investment, while more people believe that asset prices are overvalued in the hope of increasing returns, the equilibria can be spirals and even approach limit cycles. Thus, the model incorporates cyclical movements both exogenously and endogenously. Their occurrence and stability depend on the way information is disseminated and processed among traders. If agents are cautious and reduce investment when more people believe in overpricing, there are more stable equilibria and no cyclical movement is found. Furthermore, the model incorporates a "bubble threshold" to indicate when the asset price contains a bubble. Bubbles can emerge and deflate when equilibria are stable or when cycles exist. If the system moves outside the region of attraction of stable equilibria, or if equilibria are unstable, bubbles will continue to grow until they burst. This happens in both scenarios. Additionally, the

effect of increasing the interest rate is examined as a possible monetary policy to prevent bubbles. The model shows that this can be used to directly stabilize the market, but bubbles can still occur and burst. High asset price growth may be flattened, reducing investment risk.

Thus, this thesis extends the literature in which financial cycles are detected by formally modeling how such cycles arise when behavioral elements and the role of information and heterogeneous beliefs are considered. As Brunnermeier (2001) already points out, research in this context should include behavioral elements in formal models.

In an environment of increasing information, it is difficult to discern the truth. Recently, Merlino et al. (2023) study the diffusion of true and false messages in social networks, while the verification of messages is costly. In particular, the increasing use of online social media as news sources favors the spread of false news. This has been observed in various contexts, such as "fake news" during the 2016 US presidential election (Allcott & Gentzkow, 2017) or misinformation about the origin of the coronavirus (COVID-19) (Mian & Khan, 2020).

In the information acquisition process of this dissertation the choice is determined by the signals that an individual receives. If these signals contain false messages or even fake news and the individual cannot verify them, they will use such false news to update their beliefs and make a decision. For example, fake news stories can lead to a misperception of the ideological match, which can lead to the adoption of very radical belief systems. When the budget is exhausted, the individual cannot learn the true ideological match. This also applies to a consumer's purchase decision. False information signals can lead them to buy only certain products, even though others would better serve their needs. Without experiencing these other products, the consumer's beliefs cannot be corrected. This can be taken advantage of by competing companies. Furthermore, this thesis shows that the behavior of financial markets depends on the number of traders who believe that asset prices are overvalued. This number can also be influenced by false information, which can destabilize the market and even lead to the bursting of bubbles.

Therefore, further research on the role of information should examine the impact of

false information or fake news in more detail. In the Bayesian learning framework, this could be included in the signal precision or the expected value of the signal. In addition, the model of chapter 4 could be empirically tested. It would be interesting to identify the different scenarios in a time series and to find appropriate bubble thresholds. This could add to the literature on forecasting price anomalies, including bubbles.

References

Abreu, D., & Brunnermeier, M. K. (2003). Bubbles and crashes. *Econometrica*, *71*(1), 173–204. https://doi.org/10.1111/1468-0262.00393

Akerlof, G. A. (1970). The market for "lemons": Quality uncertainty and the market mechanism. *The Quarterly Journal of Economics*, *84*(3), 488–500.

Allcott, H., & Gentzkow, M. (2017). Social media and fake news in the 2016 election. *Journal of Economic Perspectives*, *31*(2), 211–236. https://doi.org/10.1257/jep.31.2.211

Allen, F., Morris, S., & Postlewaite, A. (1993). Finite bubbles with short sale constraints and asymmetric information. *Journal of Economic Theory*, *61*(2), 206–229. https://doi.org/10.1006/jeth.1993.1067

Arrow, K. J., Blackwell, D., & Girshick, M. A. (1949). Bayes and minimax solutions of sequential decision problems. *Econometrica*, *17*(3/4), 213. https://doi.org/10.2307/1905525

Ashiya, M., & Doi, T. (2001). Herd behavior of japanese economists. *Journal of Economic Behavior and Organization*, *46*(3), 343–346. https://doi.org/10.1016/s0167-2681(01)00182-2

Avery, C., & Zemsky, P. (1998). Multidimensional uncertainty and herd behavior in financial markets. *The American Economic Review*, *88*(4), 724–748.

Bellman, R. E. (1957). *Dynamic programming*. Princeton University Press.

Benartzi, S., & Thaler, R. H. (2001). Naive diversification strategies in defined contribution saving plans. *American Economic Review*, *91*(1), 79–98. https://doi.org/10.1257/aer.91.1.79

Benguria, F., & Taylor, A. M. (2020). After the panic: Are financial crises demand or supply shocks? evidence from international trade. *American Economic Review: Insights*, *2*(4), 509–526. https://doi.org/10.1257/aeri.20190533

Bernanke, B. S., & Gertler, M. (1999). Monetary policy and asset price volatility. *Economic Review*, *84*(Q IV), 17–51.

Bikhchandani, S., Hirshleifer, D., & Welch, I. (1992). A theory of fads, fashion, custom, and cultural change as informational cascades. *Journal of Political Economy*, *100*(5), 992–1026. https://doi.org/10.1086/261849

Blanchard, O. J., & Watson, M. W. (1982). *Bubbles, rational expectations and financial markets* (P. Wachtel, Ed.). Lexington Books, Lexington, MA. https://doi.org/10.3386/w0945

Bordo, M. D., Dueker, M. J., & Wheelock, D. C. (2002). Aggregate price shocks and financial instability: A historical analysis. *Economic Inquiry*, *40*(4), 521–538. https://doi.org/10.1093/ei/40.4.521

Brunnermeier, M. K. (2001). *Asset pricing under asymmetric information: Bubbles, crashes, technical analysis, and herding*. Oxford University Press.

Brunnermeier, M. K. (2008). Bubbles. *The new palgrave dictionary of economics* (pp. 1–8). Palgrave Macmillan UK. https://doi.org/10.1057/978-1-349-95121-5_44-2

Brunnermeier, M. K., & Nagel, S. (2004). Hedge funds and the technology bubble. *The Journal of Finance*, *59*(5), 2013–2040. https://doi.org/10.1111/j.1540-6261.2004.00690.x

Brunswik, E. (1943). Organismic achievement and environmental probability. *Psychological Review*, *50*(3), 255–272. https://doi.org/10.1037/h0060889

Campbell, A. (1960). *The american voter*. Wiley.

Cecchetti, S., Genberg, H., Lipsky, J., & Wadhwani, S. (2000). Asset prices and central bank policy. *Geneva Reports on the World Economy*, *2*.

Chatterjee, R. A., & Eliashberg, J. (1990). The innovation diffusion process in a heterogeneous population: A micromodeling approach. *Management Science*, *36*(9), 1057–1079. https://doi.org/10.1287/mnsc.36.9.1057

Che, Y.-K., & Mierendorff, K. (2019). Optimal dynamic allocation of attention. *American Economic Review*, *109*(8), 2993–3029. https://doi.org/10.1257/aer.20171000

Crawford, G. S., & Shum, M. (2005). Uncertainty and learning in pharmaceutical demand. *Econometrica*, *73*(4), 1137–1173. https://doi.org/10.1111/j.1468-0262.2005.00612.x

Daniel, K., Hirshleifer, D., & Subrahmanyam, A. (1998). Investor psychology and security market under- and overreactions. *The Journal of Finance*, *53*(6), 1839–1885. https://doi.org/10.1111/0022-1082.00077

DeGroot, M. H. (1970). *Optimal statistical decisions*. McGraw-Hill. https://doi.org/10.1002/0471729000

DeLong, J. B., Shleifer, A., Summers, L. H., & Waldmann, R. J. (1990). Positive feedback investment strategies and destabilizing rational speculation. *The Journal of Finance*, *45*(2), 379–395. https://doi.org/10.1111/j.1540-6261.1990.tb03695.x

Denzau, A., & North, D. (2000). Shared mental models: Ideologies and institutions. In A. Lupia, M. McCubbins, & S. Popkin (Eds.), *Elements of reason: Cognition, choice, and the bounds of rationality* (pp. 23–46). Cambridge University Press.

Drehmann, M., Borio, C., & Tsatsaronis, K. (2012). *Characterising the financial cycle: Don't lose sight of the medium term!* (BIS Working Papers No. 380). Bank for International Settlements.

Erdem, T., & Keane, M. P. (1996). Decision-making under uncertainty: Capturing dynamic brand choice processes in turbulent consumer goods markets. *Marketing Science*, *15*(1), 1–20. https://doi.org/10.1287/mksc.15.1.1

Friedrichs, J. (2002). Rational behaviour in everyday situations. *European Sociological Review*, *18*(4), 401–415. https://doi.org/10.1093/esr/18.4.401

Fritz, M., Gries, T., & Wiechers, L. (2022). *An Early Indicator for Anomalous Stock Market Performance* (Working Papers CIE No. 153). Paderborn University, CIE Center for International Economics.

Galati, G., Hindrayanto, I., Koopman, S. J., & Vlekke, M. (2016). Measuring financial cycles in a model-based analysis: Empirical evidence for the united states and

the euro area. *Economics Letters*, *145*, 83–87. https://doi.org/10.1016/j.econlet.2016.05.034

Gennotte, G., & Leland, H. (1990). Market liquidity, hedging, and crashes. *The American Economic Review*, *80*(5), 999–1021.

Gigerenzer, G. (1991). How to make cognitive illusions disappear: Beyond "heuristics and biases". *European Review of Social Psychology*, *2*(1), 83–115. https://doi.org/10.1080/14792779143000033

Gigerenzer, G., & Gaissmaier, W. (2011). Heuristic decision making. *Annual Review of Psychology*, *62*(1), 451–482. https://doi.org/10.1146/annurev-psych-120709-145346

Gigerenzer, G., & Goldstein, D. G. (1996). Reasoning the fast and frugal way: Models of bounded rationality. *Psychological Review*, *103*(4), 650–669. https://doi.org/10.1037/0033-295x.103.4.650

Gigerenzer, G., & Todd, P. M. (1999). Fast and frugal heuristics: The adaptive toolbox. *Simple heuristics that make us smart* (pp. 3–34). Oxford University Press.

Gigerenzer, G., Todd, P. M., & The ABC Research Group. (1999). *Simple heuristics that make us smart*. Oxford University Press.

Gilovich, T., Griffin, D., & Kahneman, D. (2002). *Heuristics and biases: The psychology of intuitive judgment*. Cambridge: Cambridge University Press.

Goettler, R. L., & Clay, K. (2011). Tariff choice with consumer learning and switching costs. *Journal of Marketing Research*, *48*(4), 633–652. https://doi.org/10.1509/jmkr.48.4.633

Goldstein, D. G., & Gigerenzer, G. (2002). Models of ecological rationality: The recognition heuristic. *Psychological Review*, *109*(1), 75–90. https://doi.org/10.1037/0033-295x.109.1.75

Graham, J. R. (1999). Herding among investment newsletters: Theory and evidence. *The Journal of Finance*, *54*(1), 237–268. https://doi.org/10.1111/0022-1082.00103

Gries, T., & Müller, V. (2020). *Conflict economics and psychological human needs* (Working Papers CIE No. 135). Paderborn University, CIE Center for International Economics. https://ideas.repec.org/p/pdn/ciepap/135.html

Gries, T., Müller, V., & Jost, J. T. (2022). The market for belief systems: A formal model of ideological choice. *Psychological Inquiry*, *33*(2), 65–83. https://doi.org/10.1080/1047840x.2022.2065128

Grossman, S. J., & Stiglitz, J. E. (1980). On the impossibility of informationally efficient markets. *The American Economic Review*, *70*(3), 393–408.

Gutiérrez Sanín, F., & Wood, E. J. (2014). Ideology in civil war. *Journal of Peace Research*, *51*(2), 213–226. https://doi.org/10.1177/0022343313514073

Harrison, J. M., & Kreps, D. M. (1978). Speculative investor behavior in a stock market with heterogeneous expectations. *The Quarterly Journal of Economics*, *92*(2), 323. https://doi.org/10.2307/1884166

Hauser, J. (2011). A marketing science perspective on recognition-based heuristics (and the fast-and-frugal paradigm). *Judgment and Decision Making*, *6*, 396–408.

Hayek, F. A. (1945). The use of knowledge in society. *The American Economic Review*, *35*(4), 519–530.

Hiebert, P., Peltonen, T. A., & Schüler, Y. S. (2015). *Characterising the financial cycle: A multivariate and time-varying approach* (Working Paper Series No. 1846). European Central Bank.

Hong, H., Scheinkman, J., & Xiong, W. (2006). Asset float and speculative bubbles. *The Journal of Finance*, *61*(3), 1073–1117. https://doi.org/10.1111/j.1540-6261.2006.00867.x

Hördahl, P., & Packer, F. (2006). Understanding asset prices: An overview. *BIS Papers*, (34).

Israel, M. (2005). Services as experience goods: An empirical examination of consumer learning in automobile insurance. *American Economic Review*, *95*(5), 1444–1463. https://doi.org/10.1257/000282805775014335

Jensen, R. (1982). Adoption and diffusion of an innovation of uncertain profitability. *Journal of Economic Theory*, *27*(1), 182–193. https://doi.org/10.1016/0022-0531(82)90021-7

Jordà, Ò., Schularick, M., & Taylor, A. M. (2013). When credit bites back. *Journal of Money, Credit and Banking*, *45*(s2), 3–28. https://doi.org/10.1111/jmcb.12069

Jost, J. T., Federico, C. M., & Napier, J. L. (2009). Political ideology: Its structure, functions, and elective affinities. *Annual Review of Psychology*, *60*(1), 307–337. https://doi.org/10.1146/annurev.psych.60.110707.163600

Jovanovic, B. (1979). Job matching and the theory of turnover. *Journal of Political Economy*, *87*(5), 972–990.

Kay, A. C., & Eibach, R. P. (2012). The ideological toolbox: Ideologies as tools of motivated social cognition. *The SAGE handbook of social cognition the SAGE handbook of social cognition* (pp. 495–515). SAGE Publications Ltd. https://doi.org/10.4135/9781446247631.n25

Khalil, E. L. (2011). Rational, normative and procedural theories of beliefs: Can they explain internal motivations? *Journal of Economic Issues*, *45*(3), 641–664. https://doi.org/10.2753/jei0021-3624450307

Kindleberger, C. P., & Aliber, R. Z. (2005). *Manias, panics and crashes*. Palgrave Macmillan UK. https://doi.org/10.1057/9780230628045

Klein, L. R. (1998). Evaluating the potential of interactive media through a new lens: Search versus experience goods. *Journal of Business Research*, *41*(3), 195–203. https://doi.org/10.1016/s0148-2963(97)00062-3

Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political Economy*, *74*(2), 132–157.

MacKenzie, M. J., & Baumeister, R. F. (2014). Meaning in life: Nature, needs, and myths. *Meaning in positive and existential psychology* (pp. 25–37). Springer New York. https://doi.org/10.1007/978-1-4939-0308-5_2

McCall, J. J. (1970). Economics of information and job search. *The Quarterly Journal of Economics*, *84*(1), 113. https://doi.org/10.2307/1879403

McCall, J. J. (1965). The economics of information and optimal stopping rules. *The Journal of Business*, *38*(3), 300–317.

McCardle, K. F. (1985). Information acquisition and the adoption of new technology. *Management Science*, *31*(11), 1372–1389. https://doi.org/10.1287/mnsc.31.11.1372

Merlino, L. P., Pin, P., & Tabasso, N. (2023). Debunking rumors in networks. *American Economic Journal: Microeconomics*, *15*(1), 467–496. https://doi.org/10.1257/mic.20200403

Mian, A., & Khan, S. (2020). Coronavirus: The spread of misinformation. *BMC Medicine*, *18*(1). https://doi.org/10.1186/s12916-020-01556-3

Morris, S. (1996). Speculative investor behavior and learning. *The Quarterly Journal of Economics*, *111*(4), 1111–1133.

Moscarini, G., & Smith, L. (2001). The optimal level of experimentation. *Econometrica*, *69*(6), 1629–1644. https://doi.org/10.1111/1468-0262.00259

Nelson, P. (1970). Information and consumer behavior. *Journal of Political Economy*, *78*(2), 311–329.

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1993). *The adaptive decision maker*. Cambridge University Press. https://doi.org/10.1017/cbo9781139173933

Reinhart, C. M., & Rogoff, K. S. (2009). The aftermath of financial crises. *American Economic Review*, *99*(2), 466–472. https://doi.org/10.1257/aer.99.2.466

Roberts, J. H., & Urban, G. L. (1988). Modeling multiattribute utility, risk, and belief dynamics for new consumer durable brand choice. *Management Science*, *34*(2), 167–185. https://doi.org/10.1287/mnsc.34.2.167

Romer, D. (1992). *Rational asset price movements without news* (tech. rep.). National Bureau of Economic Research. https://doi.org/10.3386/w4121

Scheinkman, J. A., & Xiong, W. (2003). Overconfidence and speculative bubbles. *Journal of Political Economy*, *111*(6), 1183–1220. https://doi.org/10.1086/378531

Scherbina, A., & Schlusche, B. (2013). Asset price bubbles: A survey. *Quantitative Finance*, *14*(4), 589–604. https://doi.org/10.1080/14697688.2012.755266

Seliger, M. (1979). The inseparability of ideology and politics: The case for a re-evaluation of the concept "ideology". *Revue européenne des sciences sociales*, *17*(46), 115–138.

Simon, H. A. (1956). Rational choice and the structure of the environment. *Psychological Review*, *63*(2), 129–138. https://doi.org/10.1037/h0042769

Simon, H. A. (1955). A behavioral model of rational choice. *The Quarterly Journal of Economics*, *69*(1), 99. https://doi.org/10.2307/1884852

Simon, H. A. (1990). Invariants of human behavior. *Annual Review of Psychology*, *41*(1), 1–20. https://doi.org/10.1146/annurev.ps.41.020190.000245

Simon, H. A. (1997). *Models of bounded rationality*. The MIT Press. https://doi.org/10.7551/mitpress/4711.001.0001

Simon, H. A., & Newell, A. (1971). Human problem solving: The state of the theory in 1970. *American Psychologist*, *26*(2), 145–159. https://doi.org/10.1037/h0030806

Sorger, G. (2018). Bubbles and cycles in the solow–swan model. *Journal of Economics*, *127*(3), 193–221. https://doi.org/10.1007/s00712-018-0638-9

Stigler, G. J. (1961). The economics of information. *Journal of Political Economy*, *69*, 213–225.

Stigler, G. J. (1962). Information in the labor market. *Journal of Political Economy*, *70*(5, Part 2), 94–105. https://doi.org/10.1086/258727

Strohsal, T., Proaño, C. R., & Wolters, J. (2019). Characterizing the financial cycle: Evidence from a frequency domain analysis. *Journal of Banking & Finance*, *106*, 568–591. https://doi.org/10.1016/j.jbankfin.2019.06.010

Temin, P., & Voth, H.-J. (2004). Riding the south sea bubble. *American Economic Review*, *94*(5), 1654–1668. https://doi.org/10.1257/0002828043052268

Tirole, J. (1982). On the possibility of speculation under rational expectations. *Econometrica*, *50*(5), 1163–81.

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology*, *5*(2), 207–232. https://doi.org/10.1016/0010-0285(73)90033-9

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185*(4157), 1124–1131. https://doi.org/10.1126/science.185.4157.1124

Ulu, C., & Smith, J. E. (2009). Uncertainty, information acquisition, and technology adoption. *Operations Research*, *57*(3), 740–752. https://doi.org/10.1287/opre.1080.0611

Verrecchia, R. E. (1982). Information acquisition in a noisy rational expectations economy. *Econometrica*, *50*(6), 1415–1430.

Wald, A. (1947). Foundations of a general theory of sequential decision functions. *Econometrica*, *15*(4), 279. https://doi.org/10.2307/1905331

Walsby, H. (1947). *The domain of ideologies : A study of the origin, development and structure of ideologies*. William MacLellan.

Welch, I. (2000). Herding among security analysts. *Journal of Financial Economics*, *58*(3), 369–396. https://doi.org/10.1016/s0304-405x(00)00076-3

Werner, J. (2018). *Speculative bubbles, heterogeneous beliefs, and learning* (2018 Meeting Papers No. 1216). Society for Economic Dynamics.

Xiong, W. (2013). *Bubbles, crises, and heterogeneous beliefs* (tech. rep.). National Bureau of Economic Research. https://doi.org/10.3386/w18905

Zhong, W. (2022). Optimal dynamic information acquisition. *Econometrica*, *90*(4), 1537–1582. https://doi.org/10.3982/ecta17787