STOCKHOLM SCHOOL OF ECONOMICS
Department of Economics
659 Degree project in economics
Spring 2021

Market Models and Uncertain Subjective Value Estimates

Ruben Åkerlund (24469) and Jakob Norling (24058)

Abstract: In microeconomic market models it is a standard assumption that actors have perfect information and act rationally. These are strong assumptions for products where the value to the consumer is subjective. We theoretically investigate the market effects of uncertainty in purchase decisions by incorporating Fechner stochastic decision models in a market model of monopolistic competition. These models provide a mechanism for errors in decision-making by subjecting the consumer's before-purchase evaluation of the product to inconsistency. The market is modeled with and without bias in the evaluation, and the effects on quantity and price, as well as consumer and producer surplus are investigated. We find that unbiased inconsistency does not affect quantity and price but decreases consumer surplus. Positive bias increases quantity, price and producer surplus, while negative bias has the opposite effect. Any bias has a negative effect on consumer surplus. Drawing from these implications we discuss how marketing is used to create positive bias in potential customers' perception of a product. The results show that there is an incentive for producers to create and reinforce positive bias, exploiting consumers' behavioral heuristics and lack of information. In so doing, the economy will suffer through some combination of reduced consumer surplus and distorted resource allocation.

Keywords: Microeconomics, stochastic decisions, bias, inefficiency, consumer surplus, resource allocation

JEL: D110, D430, D610, D810, D910

Supervisor: Karl Wärneryd
Date submitted: May 16th, 2021
Date examined: May 24th, 2021
Discussants: Nora Palm-Jensen & William Karlsson
Examiner: Johanna Wallenius

Table of Contents

Introduction

Economists often assume perfect rationality, which includes perfect information. This is a very useful, simplifying assumption, but economists generally agree that it is a departure from reality. Evidence from behavioral economics confirms this (Thaler, 2016). This has stimulated a lot of work on decision theory to explain this evidence. While that is an important first step, little work has been done on integrating such alternate conceptualizations of human decision-making into other levels of economic analysis, as far as we, the authors, know. But this is one such inquiry, at the microeconomic level.

We introduce a stochastic decision model into the market model, so that a consumer's ex ante evaluation of the good is inconsistent and varies along a distribution. We find that with unbiased estimates of subjective values, quantity and price are unaffected, while consumer surplus is lost. With biased estimates, quantities and prices may change, with positive bias being beneficial to producers. Consumer surplus decreases regardless of the direction of bias. Furthermore, if producers can influence the level of bias, they will distort resource allocation to do so, draining society's resources without benefitting society. Structural features of the market moderate whether the inefficiency in consumer surplus or resource allocation is emphasized.

Today, individuals spend a lot of time and money on goods whose value is difficult to estimate. An important example is cultural goods, including movies, literature, and video games. Not only do these goods' value have a large subjective component, but significant aspects of their consumption depend on the consumer lacking most information about the product and then being exposed to that information. That latter feature is especially at odds with the idea of perfect rationality and perfect information. However, the problem of having to estimate the value of a good applies to far more types of goods, to different degrees.

Furthermore, human perception and judgment are subject to a variety of biases, as shown by psychology and behavioral economics. These biases can arise naturally. But they can also be induced by corporations, aiming to profit by exploiting the biases in consumer judgment.

This leads to the following research question: What are the consequences of consumers having to estimate the subjective value of goods? Thoroughly answering this question naturally divides into a series of steps, which are addressed by the following sections. The first section investigates if consumer behavior deviates from perfect rationality, and if so, how, including how such decision-making can be modeled. The second section adapts partial equilibrium market models to such decision-making. The third section investigates how this model fits into the wider economy. The fourth section discusses implications.

1 Background

1.1 Utility and Rationality

The basic theory for explaining individuals' choices in an economic context is utility theory. Utility theory states that individuals make choices that maximize their utility. Utility is the welfare or satisfaction that is derived from the action and subsequent outcome. The utility yielded by some outcome depends on the individual's utility function. In the basic model each person has their own utility function that determines how they value outcomes. While different outcomes yield different utilities, the utility function for each person is consistent and predetermined. Utility models do not only model utility derived from the material value of outcomes. The utility function assigns utility values to subjective parameters such as perceived fairness and altruism for situations in which there are multiple persons. But for modeling welfare received from consumption it is necessary for utility to be derived from a personal preference parameter representing the satisfaction of consuming a good.

In consumer market models the relative marginal utility of consumption is implicitly given by the price at which an individual consumer is willing to purchase. In the supply and demand pricing model the consumption utilities for all consumers are represented by the demand curve. Each consumer has a price at which they are willing to purchase, with the aggregate of all individual purchase prices making up the demand curve for a market. An individual consumer's purchase price is an expression of the utility they would receive from the good. Their maximum price is the price at which the individual is indifferent between purchasing and spending the money on something else, reflecting that the opportunity cost in utility is equal to the utility received from the good. If the price of a good is lower than the price at which a particular consumer is willing to purchase, then the difference is the consumer surplus for that consumer. Consumer surplus may be described as the net effect on welfare from the purchase. A net gain in welfare translates to a net utility gain, meaning consumers choose to make purchases that have a positive net effect on their utility.

In many cases the outcome resulting from an action cannot be known for certain beforehand. The lack of perfect knowledge about the consequences of different actions means that there is risk or uncertainty, and actors are required to make choices based on what most likely yields the best combination of outcomes and probabilities. A famous example illustrating the problem of evaluating risky prospects is the St. Petersburg paradox. It is a game where the player flips a coin until it lands on tails. The player receives $\$2^k$ where *k* is the number of heads turned up before tails turns up. The expected value of the game is $\frac{1}{2} * 1 + \frac{1}{4} * 2 + \frac{1}{8} * 4 + \frac{1}{16} * 8 \ldots = \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2} \ldots = \infty$. The paradox is that despite the expected value being infinite, no sensible person would pay more than a fairly small amount to play the game. Therefore, Daniel Bernoulli (1738) proposed that there is diminishing utility returns to money, and that a monetary prospect should be evaluated by weighing the utility outcomes by probability, as opposed to the monetary payoffs. The expected utility of the game in the St. Petersburg paradox would then be equal to the utility of a finite amount of money, because the higher monetary payoffs do not yield proportionally high utility returns.

The behavior model where actors maximize their expected utility with diminishing utility returns to money is referred to as Expected Utility Theory. It can be shown that actors maximize their expected utility when their preferences fulfill the 4 von Neumann-Morgenstern (VNM) axioms (von Neumann and Morgenstern, 1944):

- *Completeness* - preferences are clearly formed, so that when faced with two options they either prefer one or are indifferent.
- *Transitivity* - preferences are consistent over multiple choices, such that if someone prefers A over B and B over C, they must prefer A over C.
- *Continuity* - the utility function is continuous, so that from options A and B we can create an option C by offering fractions of A and B such that $C = pA + (1 - p)B$, $p \neq 0$. If A is preferred over B the option C must then be preferred over B but be less preferable than A.
- *Independence* - the preference between two options is not affected by other options, so that if A is preferred over B, introducing an option C does not change this.

When these axioms are assumed, the Expected Utility model predicts that even when outcomes are subject to randomness, behavior is not. Preferences between options are defined and consistent, and the choices made follow those preferences.

By introducing more mechanisms, backed by experimental results, Kahneman and Tversky (1979) evolve the model into Prospect Theory (illustrated in figure 1). This theory explicitly deals with risky choices and the mechanisms that constitute the model are:

- *The Reflection Effect* - people are risk-averse for positive prospects (from diminishing utility returns to money, for instance) and risk-seeking for negative prospects.
- *Loss Aversion* - losses are perceived more negatively than gains of the same amount are perceived positively.
- *Reference States* - utility derived from an outcome is based on the change in welfare rather than the resulting absolute welfare.

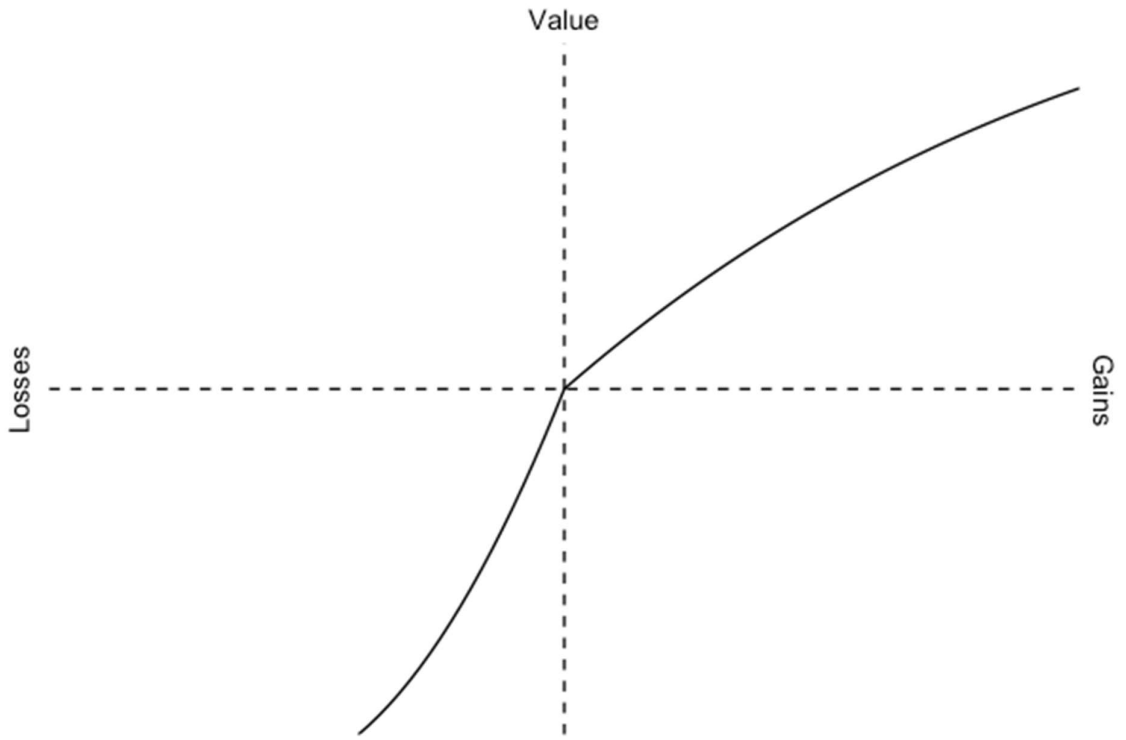

Figure 1. A prospect theory value function, adapted from Kahneman and Tversky (1979)

In addition to establishing the forementioned principles for the utility function for prospects, Prospect Theory recognizes inconsistencies in preferences due to problems with processing information. An experiment shows that people focus on the aspects of prospects that are distinct when choosing, ignoring identical components and consequently their impact on the prospects (Kahneman and Tversky, 1979). Subjects were presented with a game where they can receive either $3000 for certain or $4000 with probability 0.8 in the second round. In the first round there is a 0.25 chance of advancing to the second round and 0.75 risk of receiving nothing. The second round-award must be chosen before the result of the first round is known. Subjects who were presented with this game mostly chose $3000 for certain in the second round but subjects who were instead presented with the aggregate equivalent prospects: 0.25 chance for $3000 or 0.20 chance for $4000, mostly chose the latter. The experiment indicates that choices can be inconsistent due to problems with information processing. This is a violation of the *Completeness* VNM-axiom which holds that preferences must be consistent for equivalent choices.

In market models, it is often assumed that actors are rational, meaning they maximize their utility based on the information available to them. It is thus assumed that actors act in accordance with their goals and that they can draw conclusions about how their actions affect outcomes and how the outcomes translate to utility. For decisions under uncertainty, this means maximizing the expected utility outcome based on an understanding of the probabilities for different outcomes. The main types of deviation from rationality are first neglecting one's goals, secondly drawing wrong conclusions from the available information, leading to

unexpected outcomes (Ellingsen, 2020). These can be interpreted as errors in the execution of one's preferences, meaning the actor has set preferences, a utility function, but fails to act in accordance with their best interests. Behaving irrationally means not maximizing one's utility and as such the outcome for the actor should on average be worse than if they had acted rationally. The qualities self-control and ability to accurately process information thus help individuals achieve better outcomes. We have seen that information processing ability is generally limited. Difficulty in interpreting the available information leads to suboptimal decisions. Errors can be systematic depending on how the information is presented, meaning actors are susceptible to bias in their decisions, resulting from errors in information processing.

1.2 Common Sources of Bias

There are several instances in which humans generally deviate from optimal, rational behavior (Thaler, 1980). Experiments demonstrate that choices made by humans are often inconsistent with a rational treatment of material welfare. How prospects for material gains or losses are perceived depends on more than just the prospects, their value or expected value. Commonly observed fallacies where actors make systematic mistakes include the Sunk Cost Fallacy: not backing out of a project you have invested in, even if the future outcome is most likely negative. People also tend to treat buying and selling prices differently. They want to be paid a lot more to expose themselves to a risk than they would pay to avoid it if they were already exposed to it. For biases affecting purchasing decisions, we look at how the availability and presentation of information affect the interpretation and subsequent outcome.

Experimental work by Kahneman and Tversky (1974) shows that humans are likely to make mistakes and omissions when processing information. Subjects were asked to estimate the likelihood that a person drawn from a population of engineers and lawyers is an engineer. When given only the number of each type in the population, 70 engineers and 30 lawyers, subjects reasonably estimated the likelihood that the drawn person was an engineer to 70%. For another test, a short description of the drawn person was also provided: "Dick is a 30 year old man. He is married with no children. A man of high ability and motivation, he promises to be quite successful in his field. He is well liked by his colleagues." Although the description seems to hold no information relevant to the question of whether Dick is an engineer or a lawyer, subjects who received the description in addition to the numbers of each type estimated the likelihood of Dick being an engineer to 50%. It seems that the addition of irrelevant information caused test subjects to forget about the relevant information.

The omission of information by subjects in the experiment can be explained by a tendency to draw conclusions based on the most easily available information (Tversky and Kahneman, 1973). A set of subjects were asked to guess whether letters occur more frequently as the first letter of words or as the third letter. Only letters that occur more frequently as the third letter were presented. Still, for all these letters, most subjects thought they were more common as the first letter. These false conclusions were made because subjects made their decision based on the most easily available information. It is easier to come up with words that begin with a certain letter than words that have a certain letter in the third position. Subjects

make their guess based on words they can come up with during the short span of the test, and subjects who are unaware of the difference in difficulty finding the two different types of words will be biased towards guessing that the letter is more common in the first position.

The presence of the availability heuristic implies that there is significant difficulty in considering all available information when making decisions. The information that is considered is often that which most easily comes to mind, as in the case with guessing the most common position for letters. It can also be the information that grabs the most attention, as in the case with estimating the likelihood of drawing an engineer from a sample. Here a more salient, relatable piece of information, the description, was considered over the more relevant but less attention-grabbing sample data. The way information is presented will then have impact on how it is perceived. When asked to evaluate a mathematical expression under time constraint (5 seconds), the average answer was much higher for subjects who had to evaluate $8 * 7 * 6 * 5 * 4 * 3 * 2 * 1$ than for those who had the evaluate the expression with the numbers in the opposite order (Tversky and Kahneman, 1973). We can thus make certain pieces of information more available simply by presenting it first. Making information more memorable and salient is another way of ensuring that the information is considered when an actor evaluates a prospect. It is the work of marketers to make sure information that reflects positively on the product is memorable. With the introduction of the availability heuristic this is reflected in decision theory, because the memorable information is more likely to be considered when a consumer makes decisions.

The evidence suggests that the process of interpreting information is subject to errors and inconsistencies, not only due to difficulty in making evaluations, but also due to psychological influences. The pool of information considered is subconsciously narrowed down in decision-making processes, and information that is easily accessible is more likely considered. This would mean that the information taken into consideration may not be representative of all available information, meaning people deviate from rationality by not considering all available information. As such, bias in the information considered can lead to bias in decisions. It then follows that if the effects of information processing bias on decisions can be predicted they can be induced, as was the case above, when altered formulations of questions in experiments yielded different responses.

1.3 Decision Models

When the outcomes associated with a choice are not certain, a key result from experiments is that choices are often not consistent (Becker, DeGroot and Marschak, 1963). The uncertainty in the purchasing decision comes from the consumer's lack of information. For a purchase decision they must estimate the utility value of the product using the information that is available to them, making the outcome uncertain to the consumer. Inconsistencies in decision-making can be incorporated into decision-making models using stochastic variables. Decision-making models that incorporate stochastic variables address irrationality in decision-making by providing a mechanism that allows for deviations from rationality. Whether because actors neglect their goals or because they process information incorrectly, decision irregularities may

occur that cannot be predicted by a deterministic decision-making model. A stochastic element can be implemented in various ways, each consistent with a different interpretation of why actors make decisions inconsistently. Besides offering different justifications for randomness in decision-making, different models with different interpretations lead to different outcomes.

When weighing several options in a decision-making process, the different traits of each option are considered. In the Random Utility class of decision-making models, the traits which are considered is subject to variation (Becker, DeGroot and Marschak, 1963). When selecting what to eat for lunch one might pick something they know they like to make the decision easy, search through the menu for something they would like even more or pick something fast to save time. Perhaps they feel more hungry than usual and pick something more filling. The traits chosen when evaluating options might depend on the circumstances at a given point in time or just on what comes to mind in a given moment. The decision is then modeled by assigning probabilities to the selection of the different traits when making decisions. The probability that a person selects an option then follows from the probability of selecting traits for evaluation which favors that option. For example, if we know that the person going for lunch will choose a hamburger only when they want to save time and that the probability that they will want to save time is 30%, then the probability of choosing the hamburger is 30%. These Random Utility models thus assign probabilities to choices based on the probabilities of circumstances surrounding the decision. These circumstances might be external factors, such as the need to save time, but might also model unobservable variations in the actor's thought processes.

A set of models that more closely model errors in the execution of preferences, as is the case when an actor fails to correctly process the available information or neglects to pursue maximum utility for any reason, are Fechner models (Becker, DeGroot and Marschak, 1963). These models are variations of Random Utility models for binary choices where the utilities of the options vary along a continuous scale. Decisions follow some distribution where the likelihood of picking one choice over the other depends on the value of that choice compared to the other, according to the utility function. That is, the difference in the valuation of the two choices (A and B) carries an error term that follows some distribution. We express the probability of picking A as $A(M) = \phi(v_A - v_B)$ where M is the set $M = \{A, B\}$ and $\{v_A, v_B\}$ are the true subjective values of the options according to the utility function. Thus, the probability of choosing one option is a function of its true subjective value relative to the other option's. If a person is indifferent between the choices according to their utility function, and the error term follows a distribution that is symmetric around 0 (the valuation is unbiased), then the likelihood of picking either choice is 0.5. The probability of picking A increases when its value is greater than B, following the distribution of the error term such that B is only picked if the error term for the relative valuation $e > v_A - v_B$. In the case of a purchase decision, the choice is whether to purchase or not; as the latter is utility-neutral, this simplifies things.

The Fechner models provide a general mechanism for inconsistencies in decision-making. In contrast with standard Random Utility models, the deviations in the valuation of a proposition can vary along a continuous scale. This is particularly useful when modeling purchase decisions, where the utility expected to be derived from a product is compared to the

price. Rather than defining circumstances that lead to certain valuations of the product, we assume a fixed utility function for the consumer and expect their evaluation of the product to vary according to some distribution. The interpretation is that difficulty in gauging the utility that would be derived from the product causes inconsistent evaluations, meaning the consumer does not perfectly process the information available about the product. This is different from Random Utility models where inconsistent decisions can be interpreted as the relative preferences being dependent on circumstances. However, Random Utility models can also be interpreted as irrationality, for example, by supposing that individuals have a risk of misinterpreting their own stable utility function. While not all stochastic decision models are models of irrationality, Fechner models clearly are and model errors in preference execution.

In an experimental test of Fechner-type decision models, Hey and Orme (1994) presented subjects with 25 choices between pairs of lotteries. The lotteries were presented as circle diagrams with the slices representing probabilities for each given outcome. Subjects were asked to choose either of the lotteries or indicate indifference. The experiment thus incorporates risky choice, along with some difficulty in objectively evaluating the prospects, provided by the use of circle diagrams. The test was repeated with different ordering of the questions and answers, and the consistency of the results with various decision models were investigated. Although an Expected Utility model with no stochastic element explains the choices of many subjects well, stochastic models fit the majority of subjects better. The authors find that behavior seems to be predicted well by a model of expected utility "plus noise". That favored model would be a basic Fechner-model as described above with evaluation errors following a distribution with mean 0.

The experiment outlined above, like previously mentioned choice experiments, deal with money lotteries. The benefit of having test subjects choose between monetary prospects is that outcomes are easily comparable and their features, expected payoff and risk, can be measured completely objectively. More money yields more utility, everything else equal. The conclusions drawn from the experiments include how people value risk and how they value positive prospects compared to negative ones, as proposed in Prospect Theory. Additionally, relevant to the study of consumers choosing products are the results showing how people may interpret information inconsistently and with bias. While these experiments were done with monetary prospects, comparing the choices is a means to understanding the underlying information processing. More complex goods sold on markets have more features and these features can rarely be objectively compared. By understanding how information processing affects decisions we can make predictions for complex good markets based on heuristics and biases in actor's information processing. This means that the insights from monetary experiments most likely still apply, probably to an amplified degree.

1.4 Market Models

Stochastic decision models can be incorporated into market models by constructing a model where firms maximize profits with the knowledge that consumers act under uncertainty. Several approaches have been proposed. As Rothschild (1973) notes, some proposed models

yield the same equilibrium price as when there is no uncertainty while others find the price under uncertainty to be different from the competitive benchmark. The models that find a new equilibrium with uncertainty incorporate a mechanism where firms will exploit the customers' uncertainty, reflecting profit maximizing. A price adjustment model can be constructed in which customers are faced with the choice of whether to purchase or not. Firms set the price that maximizes profits for the expected demand function when the uncertainty is accounted for. For our model, the uncertainty lies in the valuation of the offered product. For each price and customer, the likelihood of purchase is dependent on the decision model. A Fechner model is applied to the market model so that the likelihood of purchase depends on the distribution of the decision-making error term. The stochastic element in the market model then lies in the demand of customers.

Markets in which the subjective evaluation of products beforehand is especially difficult typically have high product diversification. Whereas consumer products such as food are similar across brands, so that producers compete on price, products such as movies and books are essentially unique. These products differ in their content and the experience they give the consumer. Traits that are hard for the consumer to evaluate before the actual experience. Only one company will have the right to a specific such product. This means that consumers choose whether to purchase based primarily on the value that they have estimated compared to the price, and only to a limited extent on the price offered by other producers. The markets for these products thus have monopolistic competition, and producers decide their own prices to maximize profits.

2 Partial Equilibrium Market Models

In this framework of models, consumers purchase a good if their estimate of its subjective value exceeds the good's price. If this estimate is unbiased and has zero variance, it is identical to the standard model. Thus, perfect rationality is a special case. The key assumption of this analysis, however, is that this estimate may be subject stochastic variation and systematic biases. It is assumed that the estimate's error is normally distributed. The normal distribution has the feature of the probability density function always increasing as distance to the mean decreases. It is also symmetrical. This means that the mean is identical to the mode and median. That is, consumers will, on average, be "right" (excluding biases), by most common definitions of "average".

Additionally, further assumptions are made by default, for illustrative and simplifying purposes; however, the results are fairly robust to violations of these supporting assumptions. Such violations will be covered here and at relevant points later. These include:

- Linear demand. While this is usually not the case in reality, demand will often be approximately linear around the equilibrium price, which is where the model's departure from perfect rationality is greatest. But there are conditions where this approximation suffers, such as when unsmooth demand curves have major kinks near the equilibrium price or when the variance of the estimate is particularly large, even with smooth demand curves.

- Each unit demanded represents one individual's binary purchasing decision. The alternative interpretation where people may demand multiple units would either significantly complicate the analysis or introduce a very strong assumption. That assumption would be that the error terms for the utility of consuming different amounts of the good would be independent from each other. In reality, the opposite is likely true, with an overestimation of the first unit's value likely being repeated.
- The good is sold under the condition of monopolistic competition. Furthermore, producers' short-term marginal costs are zero. At most, other market structures and non-zero marginal costs would imply that the precise supply response might differ, but the general direction prices and quantities would move in would remain the same.

To examine the magnitude of effects, later models will be compared to a reference model which assumes perfect rationality. This model represents consumers' true preferences. That is, what they would consume and the utility level they would reach if they were not constrained by some combination of irrationality, limited computational ability, or lack of information.

Note that this is not necessarily the most "perfect" version of the market, as it is a model of monopolistic competition, a type of imperfect competition. However, monopolistic competition may be the least inefficient conceivable market when large, fixed costs would prevent firms from earning normal profits under perfect competition. Regardless, by keeping the market structure constant, the effect of variation and biases can be isolated.

2.1 The Market with Ambiguity

To isolate the effect of ambiguity from the effect of bias, consumers' estimates will be unbiased in this sub-section. Whereas the perfect rationality model represents an ideal outcome, the ambiguity model is a model of actual behavior.

The fundamental demand, representing true preferences, is stable. However, some people whose true subjective good value exceeds the price will neglect to buy the good and some people will buy the good even though it actually costs more than what they must give up to purchase it. Consumers will purchase the good when the following inequality holds:

$$V_i + e_i > P$$

Where V_i is their true subjective good value, e_i is the error of their estimate of that value, and P is the price. This error is assumed to be normally distributed with standard deviation s_e. For now, it is also unbiased ($E(e) = 0$). Under these circumstances, the probability that a consumer with a given V_i at a given price will purchase the product is:

$$\Pr(V_i + e_i > P)$$

Which can be expressed as a complementary cumulative distribution function:

$$\Pr(e_i > P - V_i) = 1 - \Phi\left(\frac{P - V_i}{s_e}\right)$$

Where Φ is the cumulative distribution function of the normal distribution. Figure 2 illustrates these probabilities.

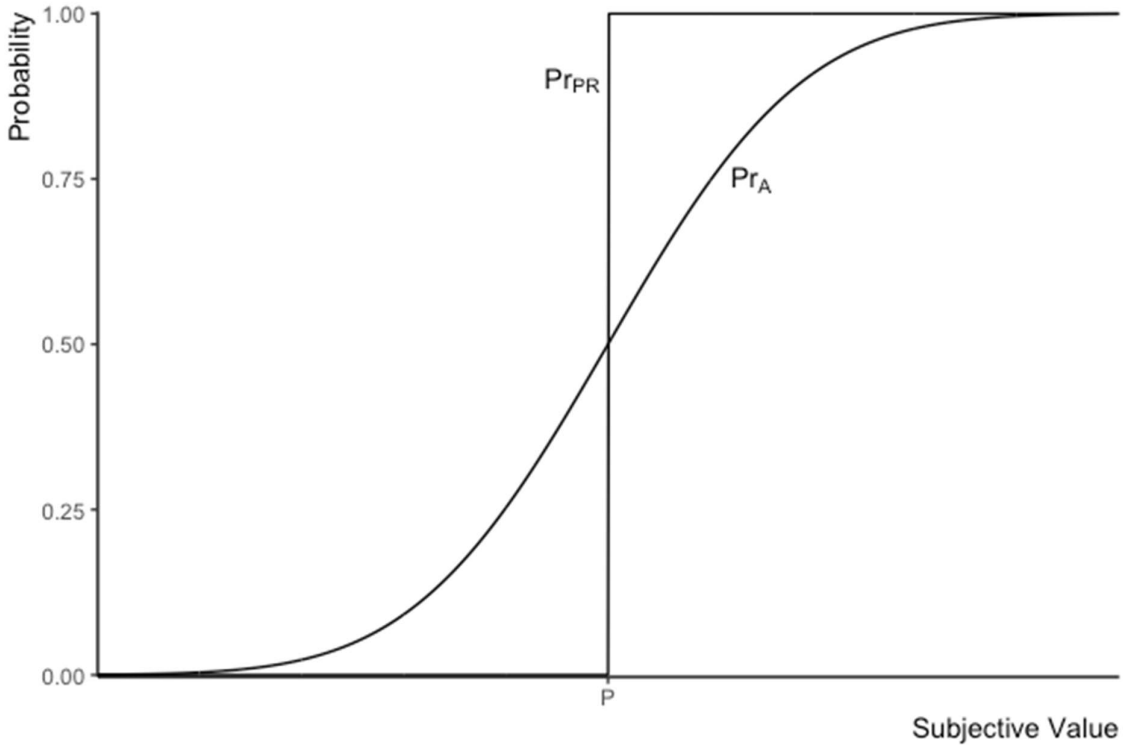

Figure 2. Comparison of the probabilities of purchasing under ambiguity and perfect rationality.

Meanwhile, in the perfect rationality model, this probability is simply:

$$\Pr(V_i > P) = \begin{cases} 1 \; if \; V_i > P \\ 0 \; if \; V_i < P \end{cases}$$

To get the quantity Q, the probability of buying the good at a particular subjective value must be multiplied by how many people have that V_i, then the expected quantity is the area underneath that curve. The distribution of V_i is the (absolute) derivative of the demand function. For linear demand, this is uniformly distributed – that is, it is flat, and thus only modifies the magnitude, not shape. For a typical, slightly curved, convex demand function, it gently slopes downward as V_i increases. These distributions and curves are shown in figure 3.

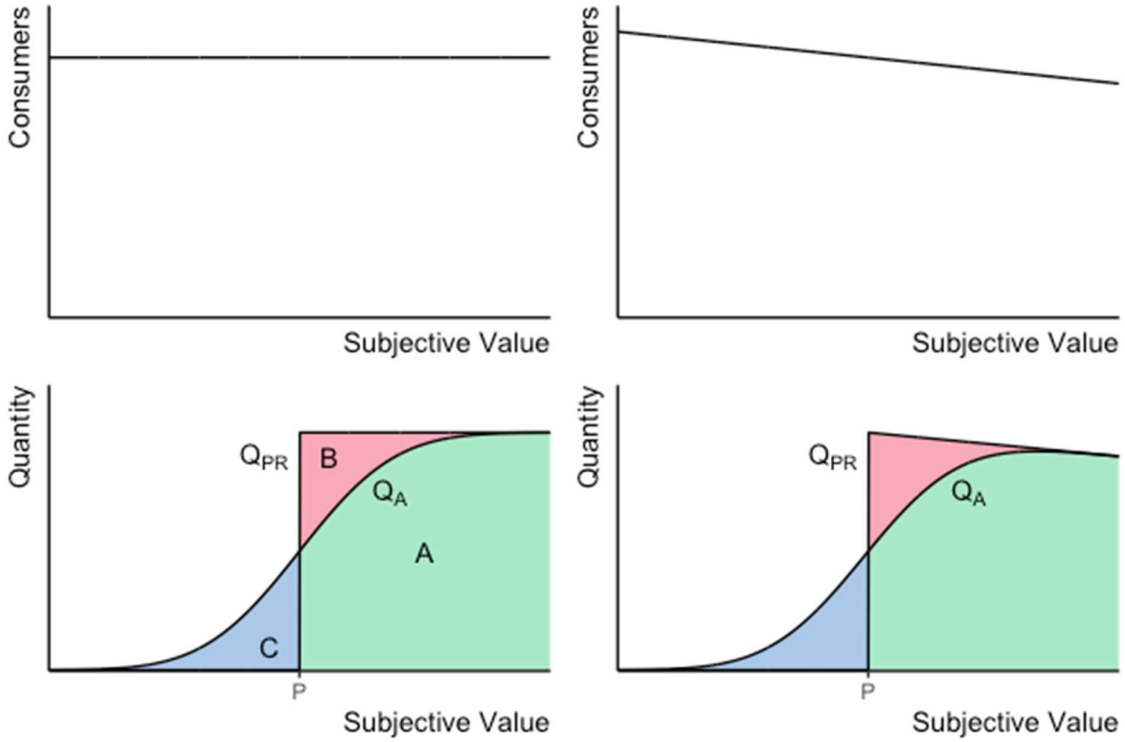

Figure 3. Expected quantities (second row) and distribution of subjective values (first row). The graphs in the left column use linear demand; the right column illustrates curved demand.

The Φ function has some important properties. It is rotationally symmetrical around $V_i = P$, where the probability is 0.5. This means that, for linear demand, the amount of people who erroneously buy the product (area C) is equal to the amount of people who erroneously do not buy it (area B) in expectation ($C - B = 0$). Thus, the expected quantity is the same for both the perfect rationality model and the ambiguity model. For curved demand, the area of additional purchases is slightly larger (amplified more) than the area of lost purchases, slightly increasing expected quantity.

The unchanged quantity in the case of linear demand implies that price will also remain unchanged. The quantity effect for curved demand, however, effectively means that demand shifts slightly outward. Producers respond to this by slightly increasing the price as well.

Producer surplus, and by extension profits, follows the pattern, with the expected value not moving for linear demand and a very small positive effect with curved demand. Note that these are expected values – actual outcomes vary. Risk-averse firms would dislike this variation, but that generally makes for a weak incentive compared to solutions' investment costs.

To illustrate consumer surplus, an additional factor must be multiplied into the previous graphs. This factor is the difference between subjective value and price, $V_i - P$, the consumer surplus for one individual (left graph in figure 4).

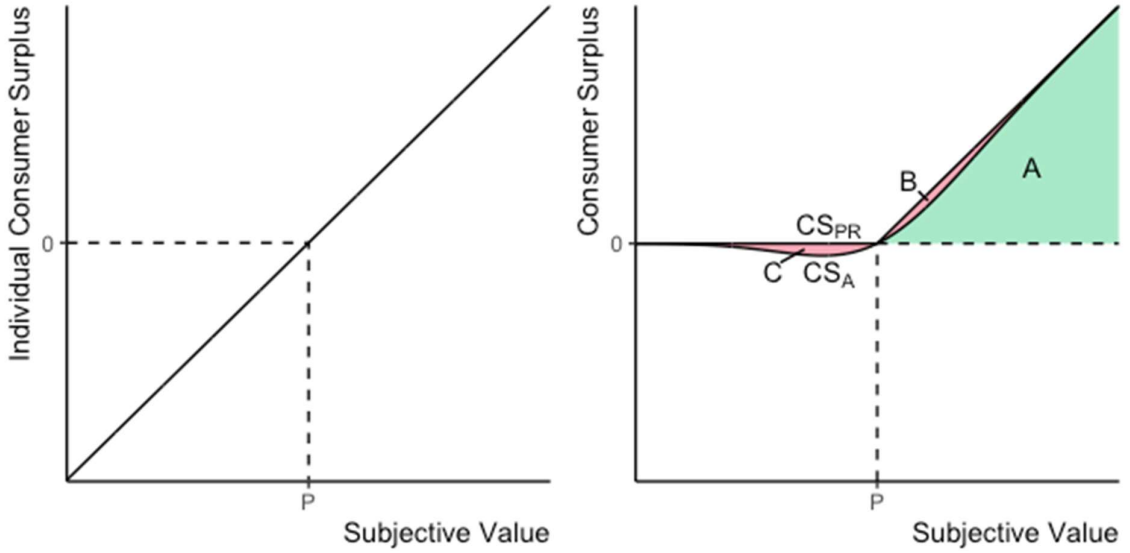

Figure 4. Expected realized consumer surplus (right) and individual consumer surplus of purchasing (left).

The right graph in figure 4 shows the product of the probability of buying the good, the amount of people, and the per-individual consumer surplus, each for every given level of subjective value. The area under the curve, but above zero (area A), represents remaining consumer surplus. But it also displays two areas of inefficiency. The area above the curve, but under zero (area C), is a consumer "deficit" (negative surplus) which consists of consumers who buy the product but would be better off not buying it. The area above the curve, but under the perfect rationality curve (area B), is those who should have purchased the product, but did not, wasting the opportunity. Note that the more likely a person is to make the wrong decision, the less impactful that decision will be, which diminishes the full extent of the effect.

The most important parameter for determining the size of these inefficiencies is the typical size of the error.[1] Increasing the standard deviation stretches the Φ curve out horizontally. This widens both deadweight losses, making them larger. Additionally, market size also matters, but only in the general sense that larger markets are more important because they involve more people and resources.

Ambiguity will not make any notable difference in key observable variables, including quantity, price, and profits. The perfectly rational model remains a good approximation of reality for these variables. But it will make a significant difference for consumer surplus – for the worse. Ambiguity does not cause inefficiencies in market production, while it does cause major inefficiencies in the allocation of goods.

[1] In the graphs, a standard deviation of 15 (compared to the demand choke price of 100) is used, for illustrative purposes. It is difficult to say whether that is larger or smaller than realistic values. On the one hand, it is easy to think of examples where one can estimate values more accurately. On the other hand, there are also cases where some people would have absolutely no idea how much something is worth.

2.2 The Market with Bias

Estimate errors need not be unbiased. There are a variety of biases and heuristics in human decision-making. Producers can intentionally tailor information with these in mind to induce exaggerated valuations. But they can also occur by chance when public misconceptions or incomplete information mislead consumers.

As in the last sub-section, consumers purchase the good when the true value offset by the error exceeds the price. Unlike the last section, the error must not be unbiased. This analysis only covers the simple case of a common mean error, $E(e) = m_e$.[2]

Changing the mean of the error alters the probability of buying the product at any specific level (note that when m_e is zero, this is equivalent to the former equation):

$$\Pr(e_i > P - V_i) = 1 - \Phi\left(\frac{P - V_i - m_e}{s_e}\right)$$

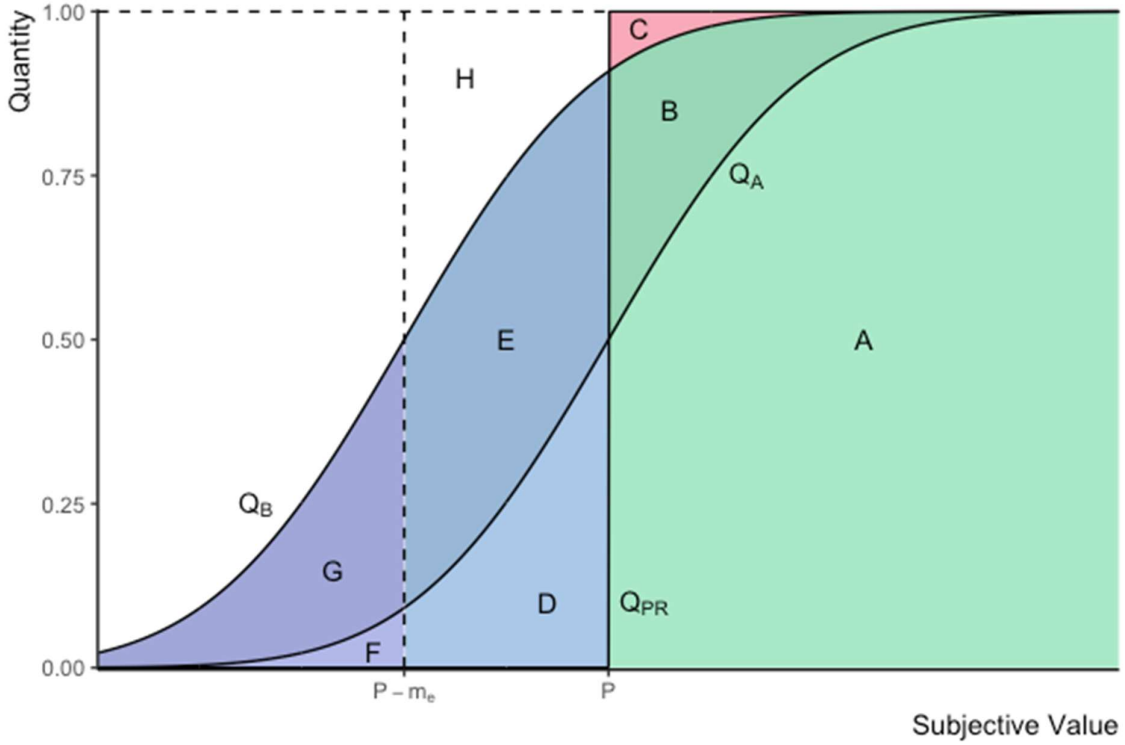

Figure 5. Expected quantities with bias, without bias, and under perfect rationality. This graph illustrates a positive bias, a negative bias would shift Q_B to the right instead.

This curve (shown in figure 5) is still rotationally symmetrical, but the point around which the curve can be rotated is moved to $V_i = P - m_e$. In the graph, the bias is positive, moving the point to the left and expanding the area representing quantity (from $A + D + F$ to $A + B + D + E + F + G$). The areas on each side of the rotation point that cancel each other out are still there (G and F vs H and C. But do note that H represents correct decisions and that they

[2] Different biases, types of needs the good fulfills, and structural features of the market can interact to alter the shape of the realized demand curve. One shift may emphasize a price change whereas another might mostly affect the quantity consumed, but whether a bias will shift the curve outward or inward should be consistent.

will now only approximately cancel each other out, as the rotation point is no longer at the center). As such, the quantity for linear demand will still be equivalent in expectation to a model where decisions are certain, but biased. A positive bias will thus, unsurprisingly, effectively shift demand outward, with a higher quantity at any price, and a negative bias inward.

Generally, the producer will raise prices for positive biases. The exact optimal response depends both on how the shape of the demand curve changed and on their marginal cost curve. With a higher price and quantity (or otherwise superior optimum), producer surplus and profits also rise. Negative biases reverse these effects. Producers are better off with positive biases, and worse off with negative biases.

For consumers, one of the two inefficiencies – people who buy the good but shouldn't and people who don't but ought – will dominate the other, depending on the direction of the bias (illustrated in figure 6). The smaller inefficiency actually shrinks compared to the unbiased model, but the increase in the larger inefficiency more than compensates for this. It also causes more consumers farther away from the perfect rationality equilibrium price to make the wrong decision – that is, unlike the pure ambiguity model, errors will not be concentrated among those who would lose the least from making the wrong decision. Consumers as a whole are worse off regardless of the direction of the bias (however, some individual consumers will be better off if the price drops, which may happen with a negative bias).

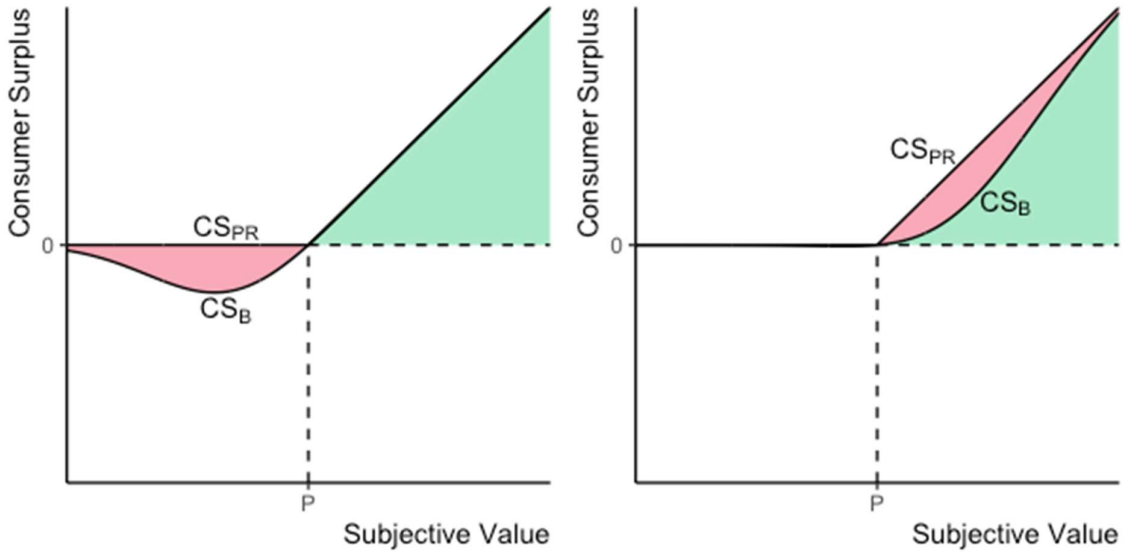

Figure 6. Expected consumer surplus for positive (left) and negative (right) bias.

With a negative bias, both consumers and producers are worse off. The total welfare effect of a positive bias is ambiguous in the short run. In the long run, more firms and substitutes would enter the greater market, or competition might intensify, pushing individual goods' demand curves down until there are no profits in the greater market. As such, the positive effect on economic profits from positive bias is dubious, while the negative effect on consumer surplus is clear.

3 The Wider Economy – Marketing and Competition

The area of business practices concerned with increasing demand is marketing, in the broadest sense (that is, not just advertising and promotions, but also various aspects of product design, distribution, and the like). In the analytical framework of this paper, there are a variety of ways the effective demand that a firm faces can change.

The level of ambiguity could change. A corporation could potentially lower the level of ambiguity by, for instance, providing well-written product information, advertising with informative commercials, or applying for certificates from independent quality organizations. In isolation, this would improve consumer surplus, but the lack of an effect on average producer surplus would make the cost difficult to justify. It may, however, be connected to rectifying negative biases, in which case the right incentives may be present.

The corporation could try to change the level of bias, but this needs to be divided into two types. The first case is when the bias term is equal to or greater than zero, and it increases. This increases the likelihood of purchase; as that is the main goal of marketing, a lot of marketing measures would fall under this category, such as advertisements appealing to emotions, presenting biased information, or exploiting decision-making biases. In this type of bias alteration, producers profit at the expense of consumers. Even if the additional profit is legitimately socially beneficial, as the cost to consumers is external, truly profit-maximizing producers would invest over the socially optimal level.

The second type of change in bias is when the bias term is negative, and the company tries to move it closer to zero.[3] The measures that intensify positive biases can be used for this as well, but there are also some measures unique to diminishing a negative bias (but if there are already positive biases in play, the final bias effect of decreasing ambiguity could actually fall into the first type). The most important of these is decreasing ambiguity when consumers are risk averse. If a consumer's estimate is just barely above the price, the chances of them having made the right decision if they buy it is roughly a coin flip. While that is utility-maximizing to a risk-neutral consumer, it might be unacceptable to one that dislikes risk, meaning that they would likely penalize their estimate. When a negative bias is addressed, consumer surplus increases, especially if it is connected to ambiguity while customers are risk-averse (as it reduces two types of harmful effects), and so does producer surplus. Again, however, the effect on consumers is external (but as this effect can eventually reverse, it is not as clear as the typical externality case, overinvestment is also possible) to a profit-maximizing firm's decision, which may lead to underinvestment compared to the socially optimal level.

Finally, the underlying demand could change, by developing consumers' preferences. This would, in a wider sense, include creating awareness that a good can satisfy a need consumers didn't know they had or had assumed would be impossible to satisfy. This effectively expands the market, but overlaps with diminishing negative biases. In this wider sense, this category also includes, for instance, adapting products according to the findings of a consumer

[3] Technically, there are even more types. If the bias moves from negative to positive, the effects are combined, and the ultimate effect on consumer surplus is ambiguous. The bias term could also decrease, but firms have no incentive to try to make that happen to their own products.

survey. In the purest sense, this is when consumers' satisfaction with a good increases because they were exposed to this instance of marketing. For instance, this could theoretically happen if a firm sets the mood for more thoroughly enjoying their product, making consumers derive more utility from it, and the consumers realize this, thus responding by increasing their willingness to pay. In isolation, this may increase both producer and potentially consumer surplus (it may, however, be paired with biases), but the consumer surplus part introduces conceptual issues regarding the stability of and basis for utility functions.

The consequences of agents' ability to influence aspects of the model warrants further discussion. Shifting preferences is one way, among other ways, in which economies change over time. Companies are most likely to address ambiguity in highly ambiguous markets or when goods are expensive (or otherwise perceived as important decisions). But even then, some level of ambiguity will likely remain, because of diminishing returns. The level of bias will depend on the competitive structure of the wider market and the nature of the marketing measures employed there.

3.1 Bias and the Structural Features of the Market

In studying the wider market, we first need to take a closer look at how subjective values form. Fundamentally, goods have use values, based on how much utility they bring. These values can depend on other variables, for instance, a good is less valuable if one has already consumed a substitute. Furthermore, goods may have different values depending on how many are consumed – that is, marginal values – which eventually lead to demand schedules. Use values are then adjusted based on other goods' use values, the consumer's budget, and prices into subjective values, which can be compared to those prices. Biases, too, are generally fundamentally pre-adjustment, influencing the base attractiveness of a good. In influencing the valuation process, they lead to post-adjustment biases.

The competitive marketing structure mainly refers to how many opportunities for investing in marketing campaigns are available to the firms. The relevant aspect of the nature of this marketing is especially whether it just redirects buyers from one firm to another or increases the total amount of money consumers spend on the broader good market (referred to as "spillover effects"[4]). When spillover effects are present, this phenomenon may not be macroeconomically neutral. The increased consumer spending on this industry must either be compensated by decreased spending in another industry or with decreased saving (or both). Whether that potential effect on saving and total consumption is a good thing or not depends on the context and which macroeconomic framework is being used. In reality, markets can have a wide variety of competitive structures and there will be nuances between different spillover effects, but only four cases will be discussed here (for supplemental examples of the cases using game theory, see appendix A).

[4] Strictly speaking, the traditional economic definition of this term would also apply to some other effects discussed here. In this sense, "spillover effects" means spillover effects that are internal to the agents (firms) in these situations, while effects on other parties are externalities.

The first case is when all actors on a market are equally capable of advertising ("advertising" will henceforth be used to refer to marketing measures aimed at creating consumer biases favorable to the advertising company) and advertising doesn't increase the total size of the consumer base – that is, no spillover effects. Actors will invest in advertising opportunities as long as the increased revenue from the additional customers exceeds the investment cost. All actors will thus invest in as many (profitable) opportunities as possible. But as they are all equally capable of doing so, they will all create the same pre-adjustment bias term. If this term was applied directly, it would imply that the total amount of purchases increased, but that is not the case. These levels are adjusted until their (weighted) average is zero. With equal advertising, this means they all return to zero, they cancel each other's advertising out. The companies receive no additional revenues but incur costs; that is, it's a prisoners' dilemma. Choosing not to advertise would mean they lose customers, which is worse. As the bias terms are nullified, consumers aren't directly harmed by a bias. However, society as a whole suffers since resources are spent unproductively. The main resource involved is labor, but other resources like machinery, energy, or raw materials may also be in use. Even if they are fairly compensated, these resources could have been employed productively to, for instance, create products or services valued by consumers.[5] Thus, in the case of symmetric marketing competition and no spillover effects, companies incur costs to no benefit while society loses due to misallocated resources, but not due to consumer biases.

The second case is when companies aren't equally capable of advertising their products. For one reason or another, some firms have competitive advantages in marketing potential. As before, all firms are still incentivized to invest in all advertising opportunities available to them. But since some corporations have more such opportunities available, they will get larger pre-adjustment bias terms. After adjustment, some companies, the ones who invested most, will have positive bias terms, while others will have negative terms. That is, the competitively advantaged firms will take customers from the disadvantaged firms, but only some customers, as they are only imperfect substitutes. Some companies win, but the industry firms still lose as a whole, as the revenue redistribution is zero-sum while the investments are negative-sum. With biases, the average consumer will diverge from the average decision they would make under perfect rationality – consumer utility will not be maximized. Resources are still not efficiently allocated, but if less than all companies can utilize an advertising opportunity, less resources can be wasted on it than if everyone could access it. In the case with competitive marketing advantages without spillover effects, some companies win and some lose, while society suffers from both consumer biases and inefficient resource allocation, but the latter effect is smaller than in the symmetric advertising case.

The third case introduces spillover effects, while returning to equal advertising capabilities. Investing as much as possible remains the dominant strategy, but each investment now increases the total revenues the firms are competing for. Post-adjustment bias terms will be equal between firms, but greater than zero. If sufficiently large, the spillover effects will

[5] This assumes that people derive no (or little) utility from being exposed to advertisements. While there are exceptions, it seems pretty safe to assume that this generally is the case.

dominate the investment costs and the situation ceases to be a prisoner's dilemma to the agents. The resource allocation problem is still large as no firms are excluded from advertising opportunities. Like the cases with competitive advantages, there are bias effects on consumer welfare. If the spillover effects are particularly large, consumer decisions may actually be more biased with symmetric advertising than with concentrated advertising. In the symmetric spillover case, the companies benefit, while society is harmed both by consumer biases and by large resource allocation inefficiencies.

The final case has both spillover effects and unequal advertising opportunities. Nothing special happens when these factors are combined. All the corporations are at least as well off as in the version without spillover effects, but how this is distributed depends on the exact specification. Conversely, the bias effect is larger than or equal to the second case. The restrictions on full resource misallocation are still there from that case. In the competitive advantage case with spillover effects, some firms win while others lose, and the effect on society from consumer biases is larger than without spillover effects while resources are misallocated less than without competitive advantages.

As such, in studying the effects of biases in more or less competitive markets, society suffers regardless of whether this causes market concentration or if they advertise equally much. However, with concentration, and when spillover effects are present, the harm from biases will be larger. With even competition, the unproductive use of resources, which can only be profited from due to consumers being vulnerable to biases, will be relatively large.

3.2 Bias and Technological Change

With technological developments, the situation this broader market faces may change (also illustrated in appendix A). The simplest type of innovation is an increase in effectiveness, which would increase the bias effect, and may justify more investments. If they innovate by decreasing resource usage, less of society's resources will be drained; but as costs are likely decreased as well, that may be offset by decreasing the pressure on firms' marketing budgets or making more opportunities profitable. More opportunities can also appear in isolation when new techniques are invented. When more advertising projects can be undertaken, companies can go deeper into advertising investments – with small or no spillover effects, this would mean delving deeper into the prisoners' dilemma. If only one or at least not all actors can pursue the opportunity, competitive advantages are created, changing the market structure. Regardless, except for innovations that decrease resource usage, these developments erode social welfare either through consumer biases or by allocating resources to unproductive purposes.

However, it must be stressed that this only applies to technological developments in one role of marketing. Positive developments in other roles could include more efficient communication of features or more accurate responses to changes in consumer tastes. As measures can fulfill multiple roles, developments could have both good and bad components. Just because a technological "improvement" is adopted, does not automatically mean that it is purely, or even mostly, beneficial to society.

4 Discussion

This paper presents theoretical models for adapting microeconomic market models to criticisms of the perfect rationality assumption, whether those criticisms be from behavioral economics, based on theoretical contradictions, or from elsewhere. The models show that, for the purposes of investigating quantities and prices, perfect rationality remains as a useful simplifying assumption, as long as biases are held constant. At most, it changes the interpretation of the demand curve from perfectly reflecting preference functions to reflecting them on average, offset by the biases of human minds.

For the purposes of utility, welfare, and the efficiency of markets, however, perfect rationality is an assumption to be wary of. The ambiguity model shows inefficiencies in the distribution of goods. The people who erroneously buy the good could exchange it at the market price with the people who erroneously do not, in which case both be better off – it fails pareto-efficiency. The bias model shows another kind of inefficiency. The bias aspect may make a small group better off, which may not fail pareto-efficiency, but would be inefficient in the same sense that monopolies are inefficient. In a broader economic context, the vulnerability to biases also causes inefficiencies in resource allocation. To be fair, the ideal market is likely not achievable, but that doesn't mean we can't come closer than we currently are.

The discriminating difference between these models and perfect rationality models lying in utility and welfare is a potential weakness of this inquiry. Utility is fundamentally unobservable, or at least very difficult to observe. This means that the implications are impossible or difficult to empirically test. However, the assumptions can be – and have been – subjected to empirical scrutiny, perhaps not perfectly, but at least in closely related situations. It has been shown that inconsistencies in decision-making may arise in situations with uncertainty and that information processing errors are often systematic. Similarly, concepts related to utility, like satisfaction and happiness, can also be tested.

The analysis predicts that heavily marketed products, such as high budget movies, may have a significant number of dissatisfied customers while still reaping large profits. Whether such an order can be sustained is debatable, but beyond the scope of this paper. Industries where producer profits may be detached from consumer surplus as a result of bias in consumers' ex ante evaluation could thus be investigated further. For example, by investigating how marketing correlates with profits compared to with customer satisfaction. The effects of widespread consumer dissatisfaction over time can also be studied. Our model predicts profits despite dissatisfaction, but the effects over time are not investigated. Producers maximizing profits through adjusting the price is endogenous to the models, consumers might adapt to this situation in other ways (exogenous to this model) that are worth investigating.

Economics has, over time, detached itself from its philosophical origins. The justification for that detachment, mainly perfect rationality (but also some safe assumptions about utility), has been weak for quite some time. As such, a discussion on the nature of utility is very much warranted, developing the foundations to make up for the flaws of perfect rationality.

The phenomena studied here are related to a couple of other theoretical economic phenomena. First of these is the Lemons Problem (Akerlof, 1970), which also studies markets

and uncertainty, but reaches wildly different conclusions. There are plenty of differences in model features to explain this, however. One important difference is where the main variation lies (objective quality and subjective preferences), another is the sellers' sensitivity to lower prices. More closely related phenomena are the winner's curse (Thaler, 1988) and postdecision surprise (Harrison and March, 1984). These use similar methods, but the scenarios in this paper do not have the mechanisms which select, and thus affect, only those bidders or alternatives with the most overestimated valuations. The mechanism that potentially generates overestimated and underestimated valuations is basically the same, though. Thus, this phenomenon can generate "cursed" individuals on both sides of the buying decision.

In the section on marketing and competition, multiple roles of marketing are discussed. One of the roles, attempting to use biases to create a more favorable perception of the good sold, reaches similar conclusions to Veblen (1904), where competition drives the usage of society's resources without creating value for society, but using modern frameworks of economics. Apart from this negative role, potentially positive roles are also highlighted.

With this in mind, society would benefit from policies and institutions that reduce sources of uncertainty and bias, or at least regulation to restrict measures that intentionally evoke biases in judgment. While abstract microeconomic analysis, like this, may yield general insights on how this can impact society, it won't yield specific policy recommendations in isolation; it is more of a tool to understand problems better. Rather, specific recommendations on how to reduce uncertainty and bias are likely to come from inquiries, informed of microeconomics and ethics, into psychology, behavioral economics, and critical analysis of marketing, which are thus very much worth conducting.

For non-rival goods microeconomics may offer some solutions addressing other aspects of the problem. Such goods include cultural goods, which may even be "anti-rival", as there are more people to discuss the experience with the more people consume it. Currently, these are excludable due to copyright laws. Various movements support alternatives to this, such as making them public goods – which removes not only the monetary cost, but also a potential Sunk Cost Bias effect on the time investment – or using deferred "pay-what-you-want" payment models. These alternatives, however, face significant issues of their own, such as incentives and fair compensation. Even so, while decreasing the cost might diminish the problem, it won't address the fundamental issue, which is more likely to be addressed when combined with research in other areas of inquiry.

Findings in behavioral economics imply that various economic theories need to be adapted. In one such adaptation, we find, on the one hand, that issues that have been relegated to the past, like efficiency of markets and abstraction of utility, may need to be revisited. On the other hand, this also raises questions for other fields, especially on the origins of uncertainty and bias as well as how these, and the negative welfare effects they bring, could be alleviated.

References

Akerlof, G. (1970) 'The Market for "Lemons": Quality Uncertainty and the Market Mechanism', *Quarterly Journal of Economics*, 84(3), p488-500

Becker, G. M., DeGroot, M. H., Marschak, J. (1963) 'Stochastic Models of Choice Behavior', *Behavioral Science*, 8(1), p41-55

Bernoulli, D. (1738) 'Exposition of a New Theory on the Measurement of Risk', Translated by Sommer L., *Econometrica*, 22(1), p23-36

Ellingsen, T. (2020) *Cooperation: A Short Introduction to Social Theory* (unpublished manuscript), Stockholm School of Economics

Harrison, J. R., March, J. G. (1984) 'Decision Making and Postdecision Surprises', *Administrative Science Quarterly*, 29(1), p26-42

Hey, J. D., Orme, C. (1994) 'Investigating Generalizations of Expected Utility Theory Using Experimental Data', *Econometrica*, 62(6), p1291-1326

Kahneman, D., Tversky, A. (1974) 'Judgement under Uncertainty: Heuristics and Biases', *Science*, 185(4157), p1124-1131

Kahneman, D., Tversky, A. (1979) 'Prospect Theory: An Analysis of Decision Under Risk', *Econometrica*, 47(2), p263-291

Rothschild, M. (1973) 'Models of Market Organization with Imperfect Information: A Survey', *Journal of Political Economy*, 81(6), p1283-1308

Thaler, R. H. (1980) 'Toward a Positive Theory of Consumer Choice', *Journal of Economic Behavior and Organization*, 1, p39-60

Thaler, R. H. (1988) 'Anomalies: The Winner's Curse', *The Journal of Economic Perspectives*, 2(1), p191-202

Thaler, R. H. (2016) 'Behavioral Economics: Past, Present, and Future', *The American Economic Review*, 106(7), p1577-1600

Tversky, A., Kahneman, D. (1973) 'Availability: A Heuristic for Judging Frequency and Probability', *Cognitive Psychology*, 5, p207-232

Veblen, T. (1904) *The Theory of Business Enterprise*, New York: Scribner's sons

von Neumann, J., Morgenstern, O. (1944) *Theory of Games and Economic Behavior,* Princeton University Press

Appendix A: Game Theory Examples

The different cases of market structure and technological changes can be illustrated using game theory examples. The following tables display two-player games where two firms can, at most, choose between not investing in advertising (A), investing in one advertising opportunity (B), or investing in two such opportunities (C). The first and second numbers are the payoffs to the row and column player, respectively; if they are exclusively profit-maximizing, this dictates their behavior. The third number is the bias effect on consumer utility, and the fourth number is the opportunity cost to society from these resource expenditures. The rules used to generate the numbers[6] are based on the effects presented earlier, but their relative strengths were arbitrarily chosen. If other relative strengths had been chosen, other effects could appear dominant. Even so, they still illustrate the general effects of movements from one set of actions to another.

	Without spillover effects				With spillover effects		
	A	B	C		A	B	C
A	0, 0, 0, 0	-10, 9, -5, -5	-18, 16, -9, -10	A	0, 0, 0, 0	-9, 10, -6, -5	-16, 18, -11, -10
B	9, -10, -5, -5	-1, -1 0, -10	-9, 6, -4, -15	B	10, -9, -6, -5	1, 1, -2, -10	-6, 9, -7, -15
C	16, -18, -9, -10	6, -9, -4, -15	-2, -2, 0, -20	C	18, -16, -11, -10	9, -6, -7, -15	2, 2, -4, -20

The equilibrium will always be the lower right corner of the available action profiles. Columns further to the right and rows further below always dominate columns to their left and rows above, respectively. However, the availability of actions is used to illustrate the various cases and developments. Note that A is always available.

In the table without spillover effects, consider symmetric competition when both firms have access to B. There is no bias effect, but a lot of resources are used. With competitive advantages, one firm has access to both B while the other does not. There is a bias effect, but less resources are used. In the table with spillover effects, the same available actions can be used to illustrate its cases. The symmetric case now has a bias effect, and the bias effect is slightly larger in the advantage case.

If a new advertising technique is invented, this represents unlocking option C. If it becomes available to both firms, resource usage increases by a lot. Additionally, with spillover effects the bias effect increases. If it only becomes available to one firm, resource usage

[6] The following rules were used to generate the numbers: Each advertising investment costs 1 payoff point, that is, B costs 1, and C costs 2. B takes 10 payoff points of revenue from the other firm, C 18. With spillover effects, each opportunity utilized adds 1 payoff point of revenues to each firm from outside the market, that is, B adds 1, and C adds 2. The bias effect is half of the ultimate reallocated payoff point revenues, either between the firms or from outside the market. This is a simplification of the model, where the marginal harm to consumers would be increasing with larger biases, as it first affects those to whom it makes a small difference to make a wrong choice, and then progressively moves toward those who have more to lose. Finally, each advertising opportunity uses resources that would have generated 5 points of utility to society in their optimal alternate use, that is, B costs 5, and C costs 10.

increases by less, but still increases. Without spillover effects, a bias effect appears, with spillover effects, it grows.

These aren't the only ways of illustrating these cases with these tables. For example, a competitive advantage in advertising can also be showed by letting one firm choose between all options, while the other only has access to A and B, or, if the advantage is particularly strong, only has access to A. But the preceding points have already been illustrated.