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Consumer Choice Behavior under Uncertainty: Extensions to Neoclassical Demand Theory

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Abstract. The purpose of this paper is to analyze the behavior of the consumer in a world under uncertainty, which goes beyond the simple scheme of the neoclassical demand theory. We read the anticipated Il volume raccoglie under a disequilibria info and not eg member opportunities in-depth of an first approach, and've how one company can suggest attached in myATT to the negative. The study explores how these theoretical developments contribute to the explanation of the market anomalies and the consumer decision-making patterns that are inconsistent with the predictions of rational choice theory. We provide empirical evidence that uncertainty affects market demand, price determination, and equilibrium. The paper also examines implications for market efficiency and welfare analysis, demonstrating how behavioral anomalies in uncertainty can result in inefficient market outcomes. We also examine the theoretical rationales for policy interventions in a market under uncertainty; and evaluate its welfare implications. The results help to build stronger psychological-economic models of consumer behavior, which forms the basis for better market analysis and policy-making under uncertainty.

Keywords: consumer choice, uncertainty, prospect theory, behavioral economics, market efficiency

1. Introduction

Classical demand theory has given economists analytic instruments of great power to describe consumer behavior or markets. The traditional approach treats consumers as rational beings who always decide optimally, with full knowledge and certainty, to maximize some utility function subject to a budget constraint. But, as Arrow [1] observed early in the evolution of economic theory, actual decisions often are taken in an environment of uncertainty, with costs and benefits not being deterministic but probabilistic. Incorporating uncertainty in economic models has indeed been crucial in explaining observed consumer behavior that is inconsistent with standard theoretical predictions. The history of economic thought has progressively emphasized the need to relinquish certainty in order to introduce elements of consumer choice behavior that are closer to reality. It allows for a more general frame on which to base economic analyses compared to a deterministic model. The Expected Utility Theory (EUT) was indeed the first cohesive attempt to integrate uncertainty into the study of economic decision making, yet empirical findings have drawn attention to sustained anomalies that cannot be readily captured within it. These critiques have led to the

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creation of alternative models integrating psychological findings into economic theory, namely behavioral economics.

This paper examines how consumer decision-making under uncertainty generalizes the neoclassical theory of demand and shapes market results. First, the basic structure of the Expected Utility Theory is considered and its axioms, principles, and criticisms are reviewed. Then, behavioral extensions such as Prospect Theory, Regret Theory, and ambiguity aversion models are explored, which try to tackle the empirical shortcomings of EUT. The paper also examines the manner in which these individual choice models aggregate at the market level and the implications this has for market demand, equilibrium formation, and welfare. Last, rationales for government intervention in uncertain markets, and welfare implications of policy measures are discussed. The novelty of this study is that it combines theoretical progression with market practice. By combining the social science disciplines of economics and psychology, the analysis of consumer behavior in conditions of uncertainty is furthered. This linkage is critical for correct market analysis, optimum policy formulation, and welfare improvements in the current very complex and uncertain economic environment. As noted by Kahneman and Tversky [2], the departures of actual behavior from the prediction of the normative model are too pervasive to be ignored, too systematic to be dismissed as random error, and too fundamental to be accommodated by so-called noise in the normative system. This motivated the conducted analysis, in which a model which takes more realistic consumer choice making into account is provided.

2. Foundations of expected utility theory

2.1. Axioms and principles

The classical theory for modeling decision-making in uncertainty is the Expected Utility Theory (EUT), which was formally introduced by von Neumann and Morgenstern [3]. It offers a normative model according to which, under certain conditions based upon axioms of rational choice, people make decisions in terms of utility maximization. It has been seminal in economics and finance because of its analytic tractability and theoretical simplicity. Knowledge of the fundamental axioms underlying EUT is critical for appreciating the strengths and limitations of EUT as a model describing consumer behavior under uncertainty. The first axiom of completeness says that for every couple of gambles/prospects, one is equally or weakly preferred to the other; that axiom is a completeness property. This second assumption guarantees that individuals can compare across all possible outcomes. The transitivity axiom ensures that preferences are transitive over alternatives: if one alternative (A) is preferred to another (B), and the latter is preferred to a third (C), then the former is preferred to the last. The continuity axiom postulates that if an alternative (say, A) is preferred to another (B), and the latter is preferred to a third (C), then a mixture with both alternatives in such proportions that the individual is indifferent between receiving one for sure and the other in a lottery occurs.

The independence axiom implies that if A is preferred to B, then a lottery offering A with probability p and C with probability 1-p must be preferred to a lottery offering B with probability p and C with probability 1-p. As Machina [4] shows, this axiom entails that preferences over prospects are independent of the common consequence. Under those axioms, an individual's preferences can be represented by a specific utility function, and decisions are driven by maximizing the expected utility across the uncertain outcomes. The policy derived from the principle of maximizing expected utility is easily articulated: multiply the personal value of each possible outcome by its probability, sum these products, and select the act associated with the greatest expected value. This method

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provides a means of introducing risk preferences in the analysis of choice. A concave utility function is an indication that the individual is risk averse (because of the decreasing marginal utility of wealth), a convex function is an indication of a risk taker, while a linear utility function indicates risk neutrality. The flexibility of EUT in modeling attitudes to risk has long ensured its popularity in the analysis of a variety of human choices, such as buying insurance or choosing a portfolio.

2.2. Applications and critiques of EUT

Due to its analytically convenient formalism and normative appeal, Expected Utility Theory (EUT) has been widely used in economics and finance. It has been established as the foundation of portfolio theory, asset pricing models, and risk management models in financial economics. EUT has implications for insurance markets; for example, the fact that risk-averse individuals may buy insurance even when they are charged a price more than the expected value of a loss. In labor economics, it is used to analyze wage differentials for risky jobs and guide decisions about investment in human capital with uncertain returns. EUT, however, has encountered considerable empirical difficulties despite being a widely adopted theory. The Allais paradox, Maurice Allais [5] was the first to show that players make systematic violations of the axiom of independence. In Allais' [5] experiments, for example, people prefer a sure option to a risky prospect with a higher expected utility in one case, but these preferences can reverse if both choices are contaminated by a third option—a direct violation of the independence axiom. The deviations are not random errors but rather reflect systematic patterns in choice processes [4]..

Another important violation of EUT is the Ellsberg paradox [6] which specifies attitudes for risk aversion against ambiguity (for known versus unknown probability distribution) that cannot be justified by EUT under any probability distribution. As an example of Ellsberg's paradox, people are likely to choose to bet on an urn with some portion of colored balls as well another with an unknown percentage of colored balls, but the chance of winning would be the same or even higher if they instead selected the second urn. This pattern is consistent with ambiguity—uncertainty about probability distributions per se—impacting choice in ways that go beyond what is captured by standard EUT. There has also been experimental evidence documenting systematic biases in probability judgments and outcome values. Furthermore, people seem to experience outcomes relative to reference points as opposed to established wealth endpoints and are more responsive to losses than equivalent gains – a bias referred to as loss aversion. These empirical problems have helped spur various alternative models that retain features of EUT but modify it in an attempt to more accurately represent behavior. Indeed, as Starmer [7] observes, the deficiencies of expected utility theory are well advertised, but it still the benchmark model of choice under risk in economics. The contrast, and sometimes tension, between the theoretical attractiveness of EUT and its empirical deficiencies has shaped a large part of the other research on consumer decision-making under uncertainty, and has led those involved to consider behavioral extensions that are discussed in the next section.

3. Behavioral extensions to choice under uncertainty

3.1. Prospect theory: a psychological alternative

One of the most prominent alternatives to Expected Utility Theory is Prospect Theory, formulated by Kahneman and Tversky [2], which remedies some of the empirical deficiencies that mar the reality of decision making, by embracing insights derived from psychology into decision making under uncertainty. Whereas EUT is concerned with final wealth states, Prospect Theory posits that people evaluate outcomes as gains or losses relative to a reference point, most often the status quo. Such a reference-based evaluation has altered the fundamental way in which risk taking is examined and anticipated. The value function for Prospect Theory possesses three essential properties which characterize it from the utility function for EUT. For one, it is defined with respect to ex post Figure 3 which is "Expected Utility Differences at Various Changes in Wealth Initial wealth of $50 and relative risk aversion level of $\gamma = 2$ (Assets)" from the report by Soder from February 6, 2006. Second, the utility function is concave with respect to the domain of gains (indicating risk-aversion), and convex with respect to the domain of losses (indicating risk seeking). This example clarifies why some people have an aversion to risk (when they buy an insurance policy), while they also can show a tendency toward risk (when they buy a lottery ticket). Third, the value function is increasing more steeply for losses than for gains, which reflects loss aversion—the empirical fact that "losses loom larger than gains" [2]. Tversky & Kahneman [8] suggested that the disutility of a loss is about twice the utility of a gain of the same amount.

The probability weighting function, which translates objective probabilities into decision weights, is another essential element of Prospect Theory. Prospect Theory, in contrast to EUT, involves perceptions of probabilities because it explains that individuals systematically misunderstand probabilities—overweight small and underweight moderate to high probabilities. This weighting function begins to explain why people buy insurance against remote calamities and lottery tickets with incredibly low probabilities of winning. As Prelec [9] observes, this S-shaped inverted probability weighting function, expresses the possibility effect of overweighting small probabilities and the certainty effect of overweighting certain outcomes. An enhancement of cumulative prospect theory by Tversky and Kahneman [10] where the weighting function is applied to cumulative rather than single probabilities, which resolves some theoretical issues with the formula proposed by Tversky and Kahneman while maintaining insights into human psychology. This provides a reconciliation between Prospect Theory and stochastic dominance, and generalizes the theory to prospects with numerous outcomes.

The predictions of Prospect Theory receive continued empirical support in a wide array of situations. For example, the disposition effect on financial markets—selling winning stocks too soon and keeping losing stocks too long—is consistent with the theory's perspectives on risk attitudes in gain and loss frames [11]. Hornbostel, Drevon, and Faust show that the endowment effect—the tendency to require a higher price to sell something than is needed to buy it—is a demonstration of loss aversion [12], which is connected to identity loss. By incorporating psychological reflections on reference points, asymmetric evaluation of gains and losses, and probability weighting, Prospect Theory presents a psychologically more realistic account of choice under uncertainty than EUT. Prospect Theory, as Barberis [13] notes, has remarkable success at accounting for many real-world stylized facts that are hard to understand from the point of view of traditional economic models.

3.2. Other behavioral models

Although PT is certainly the most relevant alternative to EUT, a number of other behavioral models have been developed to explain particular features of choice under uncertainty that are not well-described or captured by either EUT or Prospect Theory. These models provide alternative perspectives on consumer decision making and additional theoretical mechanisms to explain market outcomes in the presence of uncertainty.

Regret Theory, due independently to Bell [14] and Loomes and Sugden [15], includes the psychological element of anticipated regret or rejoicing, enabling the decision maker to attach some

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probability to possible regret, so that decisions can be made to maximize expected utility with respect to the possibility of regret or rejoicing. In contrast to the EUT that evaluates each alternative in isolation, the regret theory claims that people take into account the anticipated regret from a choice, if as a result they elect one alternative instead of another, and it turns out the latter was the better alternative. This anticipation affects current decisions, inducing behavior that violates EUT axioms. For example, regret aversion may account for the simple empirical phenomenon that people are biased in favor of conventional wisdom, despite that expected utility calculations should induce them to choose otherwise. As Loomes and Sugden [15] wrote, a fundamental premise of regret theory is that people have the feelings of regret and rejoicing and take these foreseen emotions into account when deciding under uncertainty.

Rank-Dependent Utility (RDU) variant models, introduced with Quiggin [16] and further developed by Schmeidler [17], are adjustments to the EUT that use probability weighting functions on prospects' cumulative probabilities rather than on their individual probabilities. It provides a tractable form of EU maximization while incorporating the observed probability distortions in a theoretically sound way. A class of RDU models and theories account for a number of patterns of choice that are deviations from EUT, e.g., the common consequence and common ratio effects. An important feature of RDU is that these models satisfy stochastic dominance principles, which renders them normatively more palatable than models which tolerate violations of dominance. Another important extension of the standard theory of choice under uncertainty are models of ambiguity aversion. The Ellsberg paradox showed that people are more sensitive to known risks than unknown risks, and this sensitivity can be driven by mechanisms other than EUT. Gilboa and Schmeidler's [18] maxmin expected utility model posits that when facing an ambiguous probability, a decision maker forms the worst-case belief on the set of all possible probability distributions and maximizes expected utility on this pessimistic belief. Klibanoff et al [19]. formulated a more general smooth ambiguity model which separates risk attitudes (curvature of the utility function), and ambiguity attitudes (curvature of a second-order function which evaluates expected utilities).

Case-based decision theory (CBT), developed by Gilboa and Schmeidler [20], provides a fundamentally different approach for those instances in which probabilities cannot be plausibly assigned. There is no attempt to compute expected utilities—rather agents are assumed to select actions by looking at similar past cases and remembering what worked in similar settings. This is especially important in very novel or unique decision contexts where statistical regularities are hard to establish. These alternative theories are complementary in the sense that they pertain to different (though related) aspects of choice under uncertainty. As Starmer [7] observes, every possible model of choice behaviour is likely to have some validity... the different alternatives to expected utility theory target different psychological processes that may or may not be important under different circumstances. By combining ideas from these various methodologies, researchers may construct richer models of consumer behaviour under uncertainty and the impact of that behaviour on market outcomes.

4. Market-level implications of consumer choice under uncertainty

4.1. Aggregating individual choices and market demand

The aggregation of individual consumer decisions under uncertainty shapes market demand and influences equilibrium outcomes in ways that can differ substantially from predictions based on standard deterministic models. Understanding how behavioral patterns at the individual level

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translate into market-level phenomena is essential for analyzing real-world markets characterized by uncertainty and consumer heterogeneity.

When uncertainty is present, the relationships become much more complicated and the derivation of market demand curves from individual choice functions is not straightforward. Under certain hypotheses, when consumers are homogeneous, the market demand is usually built by horizontally summing the individual demand curves. But consumers are uncertain in nature and may act as though they are subject to behavioral biases at times, resulting in aggregate demand curves with elasticities and reactive patterns potentially different from those that appear in predictions derived from deterministic models. Prospect Theory's systematic probability weighting can induce predictable distortions in market demand. The probability weighting function, in combination with commonly observed prospect theory reversals, suggests that people overweigh the importance of small probabilities in personal consumption decisions. The concept of overweighting provides a ready explanation for the popularity of personalized games of chance, such as lottery tickets, and personal investment in risky ventures, such as extended warranties. Conversely, underweighting the moderate-high probability risks could reduce demand for preventive measures with a high—but not high enough to be decisive—probability. Singh et al [21]. mention these probability distortions generate preferences that are systematically different from the market demands suggested by standard expected utility models.

There is also an effect of loss aversion and reference dependence on the aggregate demand profile, especially under markets with price dynamics. Reference prices, being established based on previous experiences by the consumers, result in price increases being seen as losses and price decreases being seen as gains. It explains how the negative response of demand to an equal price increase is stronger than the positive response to the same size of price fall. This paradox described by Putler [22] and Hardie et al [23]., also provides another reason to understand why a large number of markets may exhibit downward price stickiness—firms are hesitant to increase prices due to the fact that a considerably greater possible reduction in demand is expected. Heterogeneity in risk aversion and perception of probability across consumers also affects market demand analysis. Using the model of Dobronyi and Gouriéroux [24], the existence of markets with consumers of different risk aversions is proved, which offer demand functions that cannot be characterized as concave down somewhere for any individual consumer. For example, even though all consumers have downward sloping demand curves individually, market demand might be such that price increases can cause an increase in the quantity demanded—what is referred to as Giffen behavior in the market demand.

Table 1: Market-level effects of individual behavioral biases

Behavioral Bias	Individual-Level Effect	Market-Level Implication
Loss Aversion	Stronger response to price increases than decreases	Asymmetric price elasticities; downward price stickiness
Probability Overweighting (small probabilities)	Overvaluation of low-probability events	Excessive demand for lottery tickets, insurance for rare events
Probability Underweighting (high probabilities)	Undervaluation of high-probability events	Insufficient demand for preventive measures with high likelihood
Ambiguity Aversion	Preference for known risks over unknown risks	Premium pricing for familiar products; slow adoption of innovations
Regret Aversion	Preference for conventional choices	Herding behavior; demand concentration in established products

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The effects of these pooling influences are not confined to snapshot analyses of demand, but are also evident in dynamic market responses. The market with substantial uncertainty comes with this slow adjustment to equilibrium because consumers need time to re-estimate their probabilities and reference points. Such lagged adjustments result in temporary long-run suboptimal states in which the markets stay out of equilibrium for a long time, which might provide opportunities for firms to behave strategically or for policymakers to take action. Kashaev and Aguiar [25] conclude that dynamic random utility models that include uncertainty and learning allow us to better predict the shape of alignments in the market than static models or dynamic models without uncertainty.

4.2. Market equilibrium with uncertainty and welfare

Because of the uncertainty, market equilibria conditions and welfare results are quite different from deterministic settings. These changes have significant consequences for economic efficiency, distributional effects, and policy design. In oracles, there are many signaling aspects which might overthrow the efficiency predicted by standard competitive equilibrium: that leaves room for several valuable interventions.

In competitive markets under uncertainty, equilibrium prices are composed of a risk premium consisting of both (i) objective probability distributions and (ii) subjective risk perceptions. When consumers have biases in the way that they process information about the probability of possible future outcomes, as is empirically observed in the field of behavioral economics, market prices differ from those that would result from a return map corresponding to actual underlying probabilities. Such deviation may create market inefficiencies, so that resources are allocated inefficiently as compared to socially optimal distribution. For example, insurance markets may exhibit prices that are far in excess of actuarially fair prices, not only owing to loading costs and adverse selection but to prospect theory's probability weighting and ambiguity aversion when it comes to consumer preferences [26]. Real and financial asset markets offer among the clearest illustrations of the manner in which uncertainty influences equilibrium equilibria and the allocation of welfare. Binner and Day [27] show that various uncertainties—both over future property values, neighborhood characteristics and policy developments—can have strong effects on the formation of prices and on the distribution of welfare effects across social groups. According to their study, the structure of market forces under uncertainty and isomorphism can diffuse welfare gains across social groups in subtle, even nontrivial ways. The distributional results are complicated by housing tenure decisions (rent versus buy), and uncertainty impacts different tenure groups asymmetrically.

In the presence of uncertainty, equilibrium in financial markets does not necessarily possess the properties that "efficient market" theories predict. If investors choose according to Prospect Theory rather than EUT, asset prices may display confused movements, excessive volatility, momentum, and the equity premium puzzle—the largest historical difference between bond and stock returns that cannot be justified based on plausible levels of risk aversion under the EUT. Barberis et al [28]. illustrate how these market anomalies may be explained by loss aversion and mental accounting, and thus, how individual behavioral biases can have large and lasting consequences for the whole market.

Table 2: Market equilibrium features under different choice models

Choice Model	Key Feature	Equilibrium Implication	Welfare Effect
Expected Utility Theory	Risk aversion based on utility curvature	Risk premiums proportional to variance; complete markets efficient	First-best efficiency attainable with complete markets
Prospect Theory	Loss aversion; reference dependence	Asymmetric price adjustments; disposition effects in asset markets	Potential inefficiency due to reference-point effects
Rank-Dependent Utility	Probability weighting (cumulative)	Overpricing of small-probability risks; underpricing of high-probability risks	Inefficient risk allocation across market participants
Ambiguity Aversion	Preference for known probabilities	Innovation premium; market segmentation based on familiarity	Potential underinvestment in novel technologies
Regret Theory	Anticipation of regret influences choices	Herding phenomena; status quo bias in markets	Potential lock-in to inferior technologies or standards

The market equilibrium welfare implications under uncertainty go beyond efficiency and cover equity and distribution. Markets with uncertainty can be wealth and welfare more unequal than their corresponding certain market. These are characterized by a number of issues, including differential access to information, differences in risk-taking capabilities, and the asymmetric effects of uncertainty experienced by the most vulnerable. Jena et al [29]. observes that irrational customer behaviour under uncertainty can aggravate extant social inequalities, since disadvantaged groups often experience a greater degree of uncertainty and more restricted responses by which to manage risk. When the rationality postulates of EUT are violated, one can find cases in which market outcomes are not Pareto efficient. For example, if individuals are systematically overweighting small probabilities of large losses, they might invest too much in protecting themselves against very unlikely catastrophic events and not invest enough in protecting themselves against more likely but less severe harms. This misallocation leads to lower aggregate welfare than would occur if agents' decisions were based on their best estimates of objective probabilities. Likewise, ambiguity aversion can induce risk-averse consumers to shy away from gainful albeit unfamiliar goods or technologies, thereby generating a takeoff hurdle to adoption that restricts social welfare.

That said, it should be noted that individual irrational behavior can also serve to increase market efficiency. For example, entrepreneurial overconfidence may result in more competition and innovation in the market, thus enhancing consumer welfare due to more product diversity and lower prices, despite that many individual entrepreneurs lose money. As Jena et al [29]. call attention to, behavioral biases can occasionally have counterintuitive implications for market outcomes, which pose complex problems for welfare analysis and policy design.

5. Government intervention and consumer decisions under uncertainty

5.1. Justifications for intervention amidst uncertainty

Government interventions in markets characterized by uncertainty can be justified on both efficiency and equity grounds when behavioral biases or information asymmetries lead to suboptimal outcomes. Understanding the theoretical and empirical bases for such interventions is essential for designing policies that effectively address market failures while minimizing unintended consequences. Information asymmetries are one of the oldest rationales for government interference in markets. When consumers do not know the quality, safety, or performance characteristics of products, they may make choices that do not reflect their preferences or best interests. As illustrated by Akerlof [30] in his classic paper on the market for 'lemons,' information asymmetries can cause adverse selection and market collapse, as high-quality goods are crowded out of the market. Government policies, such as mandatory disclosure requirements, quality certification, or minimum quality standards, which will reduce consumer uncertainty and enable consumers to make more informed decisions, may help to reduce these problems.

There are also additional reasons for policy intervention with respect to behavioral biases under uncertainty. On the other hand, if consumers systematically misjudge probabilities, as reported in Prospect Theory, markets may fail to allocate resources efficiently even when information is perfect. For instance, if people underestimate low-probability, severe harms from some goods (e.g., cigarettes, alcohol, or high-return financial products), then consumption levels can be higher than is socially desirable. If, on the other hand, consumers excessively fear low-probability risks from beneficial technologies (such as vaccines or GM foods), and this causes an underutilization of such beneficial technologies, the investing activities of the firm may be impeded. Policy interventions, like taxes, subsidies, or nudges, can potentially correct these biases and push markets closer to efficient outcomes.

Table 3: Justifications for government intervention under uncertainty

Market Failure	Description	Example	Potential Intervention
Information Asymmetry	Sellers know more about product quality than buyers	Used car market; insurance markets	Disclosure requirements; consumer protection laws
Externalities under Uncertainty	Social costs/benefits not reflected in market prices, with uncertain magnitudes	Pollution with uncertain health effects	Pigouvian taxes; cap-and-trade systems
Probability Misperception	Systematic biases in assessing probabilities	Underestimation of health risks from smoking	Warning labels; taxes; education campaigns
Present Bias with Uncertainty	Excessive focus on present benefits relative to uncertain future costs	Insufficient retirement savings	Automatic enrollment in savings plans; tax incentives
Choice Overload under Uncertainty	Difficulty making optimal choices with many complex options	Health insurance markets; financial products	Standardization; default options; decision aids

When externalities and uncertainty are combined, as in both examples mentioned, the case for intervention is often very strong. When market operations give rise to external costs or benefits of uncertain magnitude and/or timing, private agents do not possess the incentives as well as quite often the information required to achieve efficient results. Climate change is the poster child: this damage (extreme in its potential severity and extreme in its uncertainty) is in the distant future and created in some way by the accumulation of greenhouse gases. As Stern [31] suggests, these circumstances warrant policy correction, such as carbon taxes or emissions trading schemes, where the extent of climate damages is still underdetermined. Considerations of fairness also justify government action in the face of uncertainty. In uncertain markets, risks and rewards are more unequally distributed, and disadvantaged people not only suffer more risks but also benefit less. This point was brought home with the 2008 financial crisis, which highlighted how financial market uncertainty can generate systemic risk that inflicts disproportionate damage on vulnerable communities in the form of unemployment, foreclosures, and cuts in public services. Government moves through financial regulation, social insurance, and targeted aid can try to ensure the burdens of uncertainty are socially borne.

The public goods character of risk reduction is an alternative motivation for intervention by the government. Many activities which reduce uncertainty – basic research, weather forecasting, public health surveillance – have public good properties (non-rivalrous and non-excludable benefits), and are underprovided in private markets. If the government shares these uncertainty-reducing activities, it may increase welfare by revealing information that contributes to better individual and social planning in uncertainty. As Pettinger [32] observed, "'Government failures in markets that are affected by uncertainty are often used to justify government intervention not only to correct market failures but also to create a more stable and predictable context in which the market economy can operate'" (p. 42). The construction of effective interventions to reduce carbon emissions would need to carefully evaluate both market failures and potential government failures, since policymakers also make their own decisions under conditions of uncertainty and may suffer from many of the same behavioral biases as private actors.

5.2. Welfare implications of policies and consumer behavior

Assessment of welfare effects of policy interventions in markets with uncertainty constitutes a major challenge in theory and practice. The combination of consumers' uncertainty and government policies gives rise to intricate dynamics that may result in welfare enhancement up to unintended harm. This highlights the importance of understanding these dynamics well in order to design policies that contribute effectively to the improvement of welfare. Price control is a widely used policy instrument with complex welfare effects under risk. There are large welfare effects if there are price ceilings or floors in markets with random demand or supply that are not present in the deterministic models. Anderson et al [33]. stated, under certain conditions, price regulation could be a Pareto superior move, especially if there are no fully functional quality or information markets. But in conditions of high uncertainty, price controls can also worsen shortages or gluts, because inflexible prices will not be able to "clear the market" according to shifts in demand or supply that materialize.

Input policies that correct behavioral biases in the face of uncertainty (so-called nudges) have been receiving more and more attention by policymakers. These interventions seek to improve decision making without impinging on freedom of choice, often by altering the choice architecture —the environment in which decisions are made. For instance, default enrollment into retirement savings accounts targets present bias and the complexity of the arithmetic, yet preserves choice by way of opt-out clauses. The welfare effects of such policies need to be evaluated, with attention to the importance of underlying heterogeneities in consumers' preferences and capabilities in the decision-making process. As Jena et al [29]. note, nudges that serve consumers who have some behavioural biases may hurt rational individuals who need to invest to opt out of the default. Information disclosure policies provide another category of interventions for uncertain markets. Such policies seek to enhance the quality of decisions by mitigating information asymmetries and by enabling consumers to make more informed choices about risks and benefits. Yet the success of information-based interventions hinges crucially on the ways in which consumers perceive and react to information. Research into disclosure requirements shows, for example, that "more" can be worse if the information is too complex or if consumers become overloaded with information [34]. Welfare-improving information policies need to consider cognitive constraints and design information that promotes better decision-making (not just more information being available).

Welfare effects of policy interventions are also highly dependent on market structure. Reed [35] demonstrates that the implications of policy intervention under uncertainty critically depend on the type and number of firms in the market. If the market is concentrated, with few firms, competition

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promoting policies could potentially lead to welfare enhancement because of lower prices and increased product variety. Yet, Crettez and Fagart [36] warn that a large number of firms, usually expected to be welfare-improving, does not always increase welfare, especially when entry results in replicating fixed operating costs with no savings in terms of prices or quality. Temporal logic is crucial to the evaluation of policies in the presence of uncertainty. Short-term, welfare-improving interventions may have distinct long-run impacts as consumers and firms adapt behaviors, learn from experience, and update their probability assessments. This dynamic response must be taken into account in policy design in order to avoid perverse incentives or lock-in effects that lead to a reduction of wellness over time. For instance, subsidies to flood insurance can be beneficial in the short run by making insurance more affordable, but detrimental in the long run by promoting development in flood-prone areas [37]. The differential effects of policies under ambiguity should be scrutinized in welfare analyses. Even policies that maximize aggregate welfare can have winners and losers, with crucial implications for fairness and political sustainability. When uncertainty differentially affects various population groups—as is frequently the case with environmental risks, health risks, or economic instabilities—policymakers ought to not only consider efficiency but also equity considerations in their responses. As Binner and Day [27] write, the distribution effects of policy interventions in face of uncertainty are often more complex and broader than simple issues of efficiency might suggest.

In the end, designing welfare-improving policy for these imperfectly competitive markets involves combining the lessons of behavioral economics, the analysis of market structure, and distributional concerns. As Farrow and Rose [38] note, the divide between academic welfare analysis and mission-oriented policy design has been narrowed by advances in behavioural economics and computational modelling, enabling policy impact assessment under uncertainty to be more realistic. This nexus promises to make interventions effective, correcting market failures and at the same time, behaving respectfully toward consumer sovereignty, and promoting efficiency and equity ends.

6. Conclusion and future directions

By include uncertainty and behavioural aspects in consumer demand research, neoclassical demand theory becomes more realistic and can account for more market outcomes and policy applications. This paper examined the shift from Expected Utility Theory to behavioural extensions, market-level implications, policy intervention motive, and uncertainty welfare implications. This study draws many key implications and suggests additional research. The empirical evidence is unequivocal that PT is better to EUT in analytical convenience and normative attraction but cannot detect consumer behaviour at risk. Systematic deviations from EUT axioms, such as independence, are too common and persistent to be considered random mistakes or experimental noise. Prospect Theory, Regret Theory, and ambiguity aversion models provide better psychologically grounded descriptions of consumer choice that account for reference dependency, loss aversion, probability weighting, and emotional responses to uncertainty. Market aggregate demand curves and equilibrium findings may diverge from neoclassical rational choice models due to individual behaviours in uncertain situations. Asymmetric pricing elasticities, disposition effects in financial markets, and excessive demand for lottery tickets or unusual event insurance are predictable results of behavioural models, yet they nevertheless confound traditionalists. These market-level impacts demonstrate the need of incorporating behavioural insights into economic modelling as processes that substantially affect market outcomes with major welfare consequences, not as psychological curiosities. The combination between unpredictable consumer behaviour and market systems creates policy difficulties and possibilities. Theories for public involvement include information asymmetries, externalities, probability misperceptions, and fairness. Welfare-improving policies should account for variation in preference and choice, policy response dynamics, and policy spillovers. In uncertain markets with behavioural biases, deterministic policy recommendations may be useless or harmful.

Consumer choice under uncertainty may be better understood and utilized via future study. Better straw horse models that bridge partial and general equilibrium analysis would enhance forecasting and policy evaluation. According to Farrow and Rose [38], advances in computational modelling are reducing the gap between theoretical welfare analysis and policy application, making it possible to evaluate interventions in complex, uncertain environments more realistically. Second, combining neuroscience, psychology, and economics might provide better integrated and empirically grounded theories of uncertainty-based decision-making. Neuroeconomics is revealing risk perception, probability weighting, and loss aversion neuronal pathways. These results may also help policymakers forecast consumer behaviour differently from rational choice models, enabling more focused and successful interventions. Third, machine learning algorithms and big data analytics for customer choice under uncertainty are a great topic for Guided Session seminars. Big data on consumer behaviour and more sophisticated analytical techniques uncover patterns and linkages that may be less obvious in experimental or survey-based investigations. Singh et al [21]. remark that machine learning-based decision modelling approaches may represent complicated nonlinear linkages and interactions that parametric models cannot specify.

Fourth, cultural, social, and environmental impacts on uncertainty-related decision-making would improve behavioural model theory and practice. There is abundant evidence that people's actions, not objects, make things unsafe or safe . Most research focuses on individual cognitive processes, although social settings impact choices, probability evaluations, and risk attitudes. Including contextual elements in economic models may improve prediction and policy relevance. Finally, policy initiatives to reduce behavioural biases under uncertainty must be assessed for ethical implications. Even with good intentions, government programs that use psychological biases to push decisions pose questions of autonomy, paternalism, and political intervention. If an intervention is to respect individual rights and increase wellbeing, these ethical considerations must be considered alongside technical economic research. Finally, uncertainty and behavioural insights in the neoclassical demand treatment have improved consumer behaviour and market outcomes comprehension. This research program has improved models of human decision making, addressed market behaviour riddles, and enabled better policy interventions to enhance outcomes by integrating psychological realism with rigorous economic analysis. This integrated approach improves understanding of the economy and policy formulation in a fundamentally unpredictable environment as knowledge and empirical operations advance.

References

[1] Arrow, K. J. (1951). Alternative approaches to the theory of choice in risk-taking situations. Econometrica, 19(4), 404-437. https: //doi.org/10.2307/1907465

[2] Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. Econometrica, 47(2), 263-291. https: //doi.org/10.2307/1914185

[3] von Neumann, J., & Morgenstern, O. (1944). Theory of games and economic behavior. Princeton University Press.

[4] Machina, M. J. (1987). Choice under uncertainty: Problems solved and unsolved. Journal of Economic Perspectives, 1(1), 121-154. https: //doi.org/10.1257/jep.1.1.121

[5] Allais, M. (1953). Le comportement de l’homme rationnel devant le risque: Critique des postulats et axiomes de l’école Américaine. Econometrica, 21(4), 503-546. https: //doi.org/10.2307/1907921

[6] Ellsberg, D. (1961). Risk, ambiguity, and the Savage axioms. The Quarterly Journal of Economics, 75(4), 643-669. https: //doi.org/10.2307/1884324

[7] Starmer, C. (2000). Developments in non-expected utility theory: The hunt for a descriptive theory of choice under risk. Journal of Economic Literature, 38(2), 332-382. https: //doi.org/10.1257/jel.38.2.332
[8] Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice: A reference-dependent model. The Quarterly Journal of Economics, 106(4), 1039-1061. https: //doi.org/10.2307/2937956
[9] Prelec, D. (1998). The probability weighting function. Econometrica, 66(3), 497-527. https: //doi.org/10.2307/2998573
[10] Tversky, A., & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty. Journal of Risk and Uncertainty, 5(4), 297-323. https: //doi.org/10.1007/BF00122574
[11] Shefrin, H., & Statman, M. (1985). The disposition to sell winners too early and ride losers too long: Theory and evidence. The Journal of Finance, 40(3), 777-790. https: //doi.org/10.1111/j.1540-6261.1985.tb05002.x
[12] Kahneman, D., Knetsch, J. L., & Thaler, R. H. (1990). Experimental tests of the endowment effect and the Coase theorem. Journal of Political Economy, 98(6), 1325-1348. https: //doi.org/10.1086/261737
[13] Barberis, N. (2013). Thirty years of prospect theory in economics: A review and assessment. Journal of Economic Perspectives, 27(1), 173-196. https: //doi.org/10.1257/jep.27.1.173
[14] Bell, D. E. (1982). Regret in decision making under uncertainty. Operations Research, 30(5), 961-981. https: //doi.org/10.1287/opre.30.5.961
[15] Loomes, G., & Sugden, R. (1982). Regret theory: An alternative theory of rational choice under uncertainty. The Economic Journal, 92(368), 805-824. https: //doi.org/10.2307/2232669
[16] Quiggin, J. (1982). A theory of anticipated utility. Journal of Economic Behavior & Organization, 3(4), 323-343. https: //doi.org/10.1016/0167-2681(82)90008-7
[17] Schmeidler, D. (1989). Subjective probability and expected utility without additivity. Econometrica, 57(3), 571-587. https: //doi.org/10.2307/1911053
[18] Gilboa, I., & Schmeidler, D. (1989). Maxmin expected utility with non-unique prior. Journal of Mathematical Economics, 18(2), 141-153. https: //doi.org/10.1016/0304-4068(89)90018-9
[19] Klibanoff, P., Marinacci, M., & Mukerji, S. (2005). A smooth model of decision making under ambiguity. Econometrica, 73(6), 1849-1892. https: //doi.org/10.1111/j.1468-0262.2005.00640.x
[20] Gilboa, I., & Schmeidler, D. (1995). Case-based decision theory. The Quarterly Journal of Economics, 110(3), 605-639. https: //doi.org/10.2307/2946694
[21] Singh, A., Liu, Y., & Yoganarasimhan, H. (2023). Choice models and permutation invariance: Demand estimation in differentiated products markets. arXiv. https: //arxiv.org/abs/2307.07090
[22] Putler, D. S. (1992). Incorporating reference price effects into a theory of consumer choice. Marketing Science, 11(3), 287-309. https: //doi.org/10.1287/mksc.11.3.287
[23] Hardie, B. G., Johnson, E. J., & Fader, P. S. (1993). Modeling loss aversion and reference dependence effects on brand choice. Marketing Science, 12(4), 378-394. https: //doi.org/10.1287/mksc.12.4.378
[24] Dobronyi, C., & Gouriéroux, C. (2020). Consumer theory with non-parametric taste uncertainty and individual heterogeneity. arXiv. https: //arxiv.org/abs/2010.13937
[25] Kashaev, N., & Aguiar, V. H. (2022). Nonparametric analysis of dynamic random utility models. arXiv. https: //arxiv.org/abs/2204.07220
[26] Kunreuther, H., Hogarth, R., & Meszaros, J. (1995). Insurer ambiguity and market failure. Journal of Risk and Uncertainty, 7(1), 71-87. https: //doi.org/10.1007/BF01211674
[27] Binner, A., & Day, B. (2017). How property markets determine welfare outcomes: An equilibrium sorting model analysis of local environmental interventions. Environmental and Resource Economics, 69(4), 733-761. https: //doi.org/10.1007/s10640-016-0101-8
[28] Barberis, N., Huang, M., & Santos, T. (2001). Prospect theory and asset prices. The Quarterly Journal of Economics, 116(1), 1-53. https: //doi.org/10.1162/003355301556310
[29] Jena, S. D., Lodi, A., & Sole, C. (2021). On the estimation of discrete choice models to capture irrational customer behaviors. arXiv. https: //arxiv.org/abs/2109.03882
[30] Akerlof, G. A. (1970). The market for ”lemons“: Quality uncertainty and the market mechanism. The Quarterly Journal of Economics, 84(3), 488-500. https: //doi.org/10.2307/1879431
[31] Stern, N. (2007). The economics of climate change: The Stern review. Cambridge University Press.
[32] Pettinger, T. (2019). Government intervention in markets. Economics Help. https: //www.economicshelp.org/microessays/equilibrium/govt-intervention/
[33] Anderson, R. K., Enomoto, C. E., & Maurice, S. C. (1989). Welfare implications of price regulation: A general equilibrium analysis. Studies in Economics and Finance, 12(2), 92-120. https: //doi.org/10.1108/eb028686
[34] Eppler, M. J., & Mengis, J. (2004). The concept of information overload: A review of literature from organization science, accounting, marketing, MIS, and related disciplines. The Information Society, 20(5), 325-344. https:

//doi.org/10.1080/01972240490507974
[35] Reed, J. (2019). What are the effects of government intervention? ReviewEcon.com. https: //www.reviewecon.com/what-are-the-effects-of-government-intervention
[36] Crettez, B., & Fagart, M. C. (2009). Does entry improve welfare? A general equilibrium approach to competition policy. Journal of Economics, 98(2), 97-118. https: //doi.org/10.1007/s00712-009-0082-y
[37] Kunreuther, H., Heal, G., Allen, M., Edenhofer, O., Field, C. B., & Yohe, G. (2013). Risk management and climate change. Nature Climate Change, 3(5), 447-450. https: //doi.org/10.1038/nclimate1740
[38] Farrow, S., & Rose, A. (2018). Welfare analysis: Bridging the partial and general equilibrium divide for policy analysis. Journal of Benefit-Cost Analysis, 9(1), 67-83. https: //doi.org/10.1017/bca.2017.29