

# Dynamic Purchase Decisions Under Regret: Price and Availability

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We model a dynamic purchase context in which a consumer is uncertain about the product's valuation. The consumer has two purchase opportunities for the product: forward purchase in Period 1 or spot purchase in Period 2. Two forms of regret are considered: buyer's regret over the money paid in excess of his valuation of the product when buying forward and hesitater's regret for the lost opportunity of an increased surplus when not buying forward. We illustrate how regrets affect the purchase decision: a consumer is more likely to buy forward when more averse to hesitater's regret but more likely to delay the decision when more averse to buyer's regret. We also consider alternative consumer types to characterize how regret affects their spot purchase decisions as well as what triggers the regret. We show that type inconsistency—that is, a consumer's incorrect anticipation of his future type—induces an inferior Period 1 purchase decision and thereby reduces the consumer's expected surplus.

*Key words:* regret; consumer behavior; dynamic purchase; type inconsistency

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## 1. Introduction

We study the impact of regret on the consumer's decision making in a dynamic purchase context. Under regret theory (Bell 1982, Loomes and Sugden 1982, Fishburn 1991), the decision maker compares the option chosen with the forgone option, and this comparison can trigger regret (respectively, a feeling of "rejoice" in the terminology of Loomes and Sugden 1982) if what the decision maker obtains is lower (respectively, higher) than what would have been obtained with a different choice. Regret theory allows explaining some of the most common behavioral regularities in economics and management (Loomes and Sugden 1982) and hence has become a descriptively appealing alternative to expected utility (von Neumann and Morgenstern 1947). A good body of literature in psychology emphasizes the importance of regret in shaping people's preferences under risk (e.g., Larrick 1993, Zeelenberg et al. 2002). Smith (1996) and Yaniv (2000) analyze the role of regret in medical decision making. In economics and finance,

Gollier and Salanié (2006) and Muermann et al. (2006) incorporate regret into models of asset pricing and portfolio choice, Braun and Muermann (2004) show that regret can explain the commonly observed preference for low deductibles in personal insurance markets, Barberis et al. (2006) use regret to explain why people tend to invest too little in stocks, Michenaud and Solnik (2008) show that regret can explain empirically observations that many investors do not adopt a full hedging policy with respect to currency risk, and Muermann and Volkman (2007) show how regret can explain the disposition effect (Shefrin and Statman 1985). Regret preferences are applied by Perakis and Roels (2008) to the newsvendor model, by Nasiry and Popescu (2012) to advance selling, and by Filiz-Ozbay and Ozbay (2007) and Engelbrecht-Wiggans and Katok (2008, 2009) to auctions. Regret has been successfully introduced in economic and managerial modeling as a psychologically valid feature of individual behavior. To date, to the best of our knowledge, there is not a sound regret-based model that

provides an exhaustive characterization of consumer behavior in a dynamic purchase context. Introducing such a descriptive model is the purpose of the current paper.

A consumer can buy early or delay the buying decision until later. Although buying late (spot purchase) is done with better information, potential reasons to buy early (forward purchase) include lower price and guaranteed availability.<sup>1</sup> Two forms of regret naturally arise: *buyer's regret*, the regret of having bought early, and *hesitater's regret*, the regret of hesitating (i.e., of not having bought early). We consider the case where the consumer, when deciding whether or not to buy early, anticipates regret and takes it into consideration (Zeelenberg 1999a). Following Engelbrecht-Wiggans and Katok (2008), we assume that (a) the anticipated regret enters additively into a consumer's surplus, and (b) the effect of regret on a consumer's surplus is proportional to the amount of forgone surplus. Then buyer's regret refers to the regret attributable to the amount of money a consumer paid in excess of the product's valuation, and hesitater's regret refers to the regret due to the forgone opportunity of an increased surplus. These two forms of regret are equivalent to winner's and loser's regret in Engelbrecht-Wiggans and Katok (2008). They are also related to psychological findings on action and inaction regret (Gilovich and Medvec 1995) as well as to commission and omission regret (Kahneman et al. 1982). Winner's, action, and commission regret correspond to our buyer's regret; loser's, inaction, and omission regret correspond to our hesitater's regret. Note, however, that in this paper regret has a dynamic nature, whereas in the cited papers regret is static.

Our main contribution is twofold. First, we believe that the dynamics of time are essential to the full characterization and understanding of regret. To reflect this consideration, we formulate a parsimonious two-period model that offers new insights into the dynamics of regret in consumer behavior: buying forward in Period 1 may lead to buyer's regret if the consumer discovers in Period 2 that the product is of less value

to him than the price paid; delaying the purchase decision to Period 2 may trigger hesitater's regret caused by missing a discount or facing limited availability. Second, we model alternative consumer *types* in terms of how regret affects their spot purchase decisions and what triggers the regret, which in turn influence the consumer surplus. We also address the phenomenon of potential type inconsistency, in which a consumer's anticipation of his future type differs from the actual type. As pointed out in Zeelenberg's (1999b, p. 333) overview paper: "Although we have seen that people take regret into account when they know they will experience it, it is still crucial that they make correct predictions of the intensity of their possible future regret. The prediction of future emotions has not been studied extensively." To our knowledge, we are the first to analyze how inconsistency in consumers' anticipation of type influences decisions and emotions in a formal model under regret. We believe that this compact model constitutes a tractable basis for future theoretical and empirical analysis of and applications to consumer behavior and management.

## 2. Model Under Regret Neutrality

In this section, we present a two-period model as a natural normative benchmark that describes the behavior of a regret-neutral consumer under a dynamic purchase context, as illustrated in the following two examples. Such modeling approach has been widely used in the literature (Dana 1998, Gundepudi et al. 2001, Xie and Shugan 2001, Shen and Su 2007, Su 2009); specifically, we use the setting of the Gundepudi et al. (2001) two-period model of early-order discount, and we extend it to include uncertain availability.<sup>2</sup>

**EXAMPLE 1 (EARLY-ORDER DISCOUNT).** The renowned summer ball of a famous multinational institution was to be held on May 15, 2010, in a prestigious location in Europe. Two types of tickets were offered by the organizers: a regular ticket for €210 and an "early bird" ticket, for €175, that had to be purchased by April 21. Delphine, an administrative assistant in the operations department, was not sure whether to purchase early or to wait until May 15. This decision

<sup>1</sup> In this paper, we do not consider "strategic consumers" who would forward-look, purchase from speculators, or anticipate product stockouts before visiting the seller (Su and Zhang 2008, 2009; Su 2010).

<sup>2</sup> Furthermore, it can be easily extended to include uncertain price in Period 2.

depended on the weather risk, on whether she had other opportunities (such as party invitations) on that day, on which of her friends would be going, and on whether she would still have the same boyfriend, who was also planning to go.

**EXAMPLE 2 (UNCERTAIN AVAILABILITY).** Tickets for PJ Harvey’s concert in Paris—scheduled for May 17, 2009—were available three months in advance. Our colleague Jürgen was thinking of buying a ticket early because he feared they would sell out quickly. However, he was not sure whether, before the concert, he could finish writing a paper important for his tenure or whether or not his friend Dana would be able to go.

These two examples illustrate that the trade-off between forward purchase and spot purchase is commonly observed in the market for a product whose valuation to the consumer is contingent on future circumstances. Whereas buying forward often yields a discount and assured availability, buying later allows the consumer more time to establish the product’s true valuation. This dynamic purchase context can be stylized as follows. A consumer has two purchase opportunities for a product: *forward purchase* in Period 1 and *spot purchase* in Period 2. The consumer’s valuation  $V$  for the product is a random variable realized in Period 2, and the price  $p$  for the product in Period 2 is exogenously given. If the consumer makes the purchase in Period 1—that is, when facing uncertain  $V$ —then the forward purchase price is  $(1 - z)p$ ; here the discount  $z \in [0, 1)$ , and the product’s availability is ensured. If the consumer delays the purchase decision until Period 2, then he can observe his true valuation of the product and choose whether or not to buy it at the spot purchase price  $p$ , although the product may no longer be available. We denote the availability of the product in Period 2 as event  $A$  (true with probability  $\phi \in (0, 1)$ ), where  $\mathbf{1}_A = 1$  if the event is true (the product is available for the consumer), and  $\mathbf{1}_A = 0$  otherwise. We further assume that  $V$  and  $A$  are uncorrelated.

Define the consumer’s surplus as the difference between his valuation of the product and the price paid, and assume that the consumer is an expected surplus maximizer. In Period 1, the consumer compares the expected surplus of buying forward,

$\mathbb{E}_V[V - (1 - z)p]$ , with the one derived from delaying the decision until Period 2,  $\mathbb{E}_{V,A}[\mathbf{1}_A(V - p)^+]$ ; after making this comparison, the consumer decides whether or not to buy forward.<sup>3</sup> The consumer’s Period 1 purchase decision under regret neutrality is summarized in the following lemma. (All proofs are provided in Appendix B.)

**LEMMA 1.** *An arbitrary regret-neutral consumer buys forward if and only if*

$$zp + (1 - \phi)\mathbb{E}_V(V - p)^+ \geq \mathbb{E}_V(p - V)^+. \quad (1)$$

*In the case of guaranteed availability in Period 2, the inequality (1) becomes  $zp \geq \mathbb{E}_V(p - V)^+$ ; in the case of no forward purchase discount, (1) becomes  $\phi \leq \mathbb{E}_V(V - p)/\mathbb{E}_V(V - p)^+$ .*

Lemma 1 describes the consumer’s trade-off when making a forward purchase decision. The terms  $zp$  and  $(1 - \phi)\mathbb{E}_V(V - p)^+$  denote, respectively, the discount and ensured availability benefits from buying forward. The term  $\mathbb{E}_V(p - V)^+$  denotes the expected loss of surplus incurred by not waiting until Period 2 to discover the product’s true valuation.

### 3. Model Under Regret

We motivate the introduction of the model under regret with the following three reasons: (i) Hoch and Loewenstein (1991, p. 492) argue that to understand consumer behavior we must recognize that consumers are influenced “by long-term rational concerns *and* by more short-term emotional factors.” Regret is a natural candidate to describe emotional factors underlying consumer behavior especially in dynamic settings Hoch and Loewenstein (1991). (ii) The tension between the short and long term generates interesting issues. For example, there is a large body of evidence pointing to the description of suboptimal behavior in dynamic settings (Frederick et al. 2002). Dynamic consistency requires that the sequential choices made by the consumer have to be connected in a consistent

<sup>3</sup> We denote  $a^+ = \max(0, a)$  and  $a^- = -\min(0, a)$ . If the consumer chooses not to buy forward, then he observes the realization of his valuation  $V$  in Period 2 and makes the spot purchase if and only if doing so yields a nonnegative surplus (i.e., if and only if  $V - p \geq 0$ ).

manner. Under expected utility, beliefs should be consistent with Bayesian updating. However, robust violation of consistency (Frederick et al. 2002) and updating (Edwards 1961, El-Gamal and Grether 1995, Holt and Smith 2009) are documented. These violations and anomalies require modeling outside the domain of expected utility. (iii) It has been suggested that consumer behavior in dynamic settings could be modeled by risk attitudes (Xie and Shugan 2001). However, the impact of risk attitude on consumer behavior is not fully clear. Furthermore, Hoch and Loewenstein (1991), Zeelenberg (1999a), and Inman and Zeelenberg (2002) support that one of the important drivers in consumer behavior is the negative emotion of regret. With this motivation in mind, we introduce a model based on linear utility by letting the attitude with respect to regret to carry the weight of the behavioral explanation. Linear utility for small stakes, such as those consumers face, has been justified, for example, by Rabin (2000). It is not clear how regret attitudes contribute to risk attitudes (Zeelenberg et al. 1996, Bleichrodt et al. 2010), and therefore their interaction is a future topic for empirical analysis.

Overall, we seek to model, in a descriptively appealing way, the existing gap between the rational concerns and the emotional factors in such a way as to isolate regret from risk attitude. Furthermore we consider the natural extension of regret to dynamic decisions. All notation is as defined in §2, and the consumer's surplus now includes the disutility of anticipated regret. In Appendix A we offer an analysis that incorporates both "regret" and "rejoice" (Loomes and Sugden 1982).

### 3.1. Period 2

Conditional on the consumer not having purchased in Period 1, we consider his spot purchase decision in Period 2. Before proceeding, we describe the consumer's regret types according to two criteria: how regret affects the spot purchase decision and what triggers the regret.

**3.1.1. Spot Purchase Decision: Pragmatic vs. Regret Reflecting.** We consider two possible types of consumer with respect to the spot purchase decision: *pragmatic* and *regret reflecting*. A pragmatic consumer does not let regret affect his decision on whether or not to buy in Period 2 and thus makes the purchase

as long as the product's valuation exceeds its price (i.e., when  $V - p > 0$ ). A regret-reflecting consumer, in contrast, will buy in Period 2 only if the surplus exceeds the regret of having forgone the discount  $zp$  in Period 1. The literature on satisfaction and regret (Tsiros and Mittal 2000, Cooke et al. 2001, Mellers and McGraw 2001, Inman and Zeelenberg 2002) supports the introduction of the regret-reflecting type. They report that in consumer choice, when the unobtained outcome was more desirable, the consumer satisfaction (anticipated pleasure) about the obtained outcome declined. In our setting, forward purchase opportunity plays the role of the unobtained option, and the spot purchase opportunity as the obtained option. Therefore, after learning that the unobtained option (forward purchase) would have led to a better outcome, the regret reflecting consumer finds the obtained option (spot purchase) less attractive. On the other hand, Huber et al. (1982) show how consumer choice is influenced by adding a new alternative. In our setting, by learning the outcome of the unobtained option, the consumer has a lower valuation of the obtained option, and therefore alters his choice/decision regarding whether he should buy on spot or not.

**3.1.2. Regret Experience: Buy vs. Always.** We also consider two possible consumer types in terms of how regret is triggered after the spot purchase decision is made: *buy* and *always*. A "buy" consumer experiences regret only in the case of actually making the purchase. Hence, upon purchase, his regret is proportional to the amount he overpaid relative to the case of purchasing in Period 1—in other words, it is proportional<sup>4</sup> to  $zp$ . An "always" consumer, on the other hand, experiences regret regardless of whether the spot purchase is actually made. If he buys, then he regrets the amount he overpaid,  $zp$ ; if he does not buy, then he regrets the positive amount that he could have obtained had he purchased in Period 1,  $(V - (1 - z)p)^+$ . The objective of the introduction of the buy type, compared to the always type, is to capture the two extremes of nonpurchase regret: no regret at

<sup>4</sup> We remark that a pragmatic consumer could make a spot purchase and be worse off by having done so. Although this does not make much practical sense, we describe this case here for completeness.

all and the standard amount of regret. This is consistent with the regret heterogeneity detected by Patrick et al. (2003) when investigating the extent of regret experimental subjects experienced due to purchase or nonpurchase.

Define  $\beta$  and  $\eta$  as the intensity of buyer's and hesitater's regret, respectively. Let  $P$  stand for the case when the consumer is of type *pragmatic*, let  $R$  stand for *regret-reflecting*, let  $B$  stand for *buy*, and let  $W$  stand for *always*. A consumer in Period 2 is therefore one of four possible types: PB, PW, RB, or RW. These four types completely characterize how regret affects consumers' spot purchase decisions and what triggers the regret. In the interest of parsimony, our model focuses on the extreme possibilities; a real consumer's behavior would, in general, lie in the interior. The following lemma describes a consumer's surplus under these four combined types.

LEMMA 2. *The surpluses in Period 2 for consumers of type PB, PW, RB, and RW are given by*

$$\begin{aligned}\mathcal{S}_2^{\text{PB}} &= \mathbf{1}_{V-p>0,A}(V-p-\eta zp), \\ \mathcal{S}_2^{\text{PW}} &= \mathbf{1}_{V-p>0,A}(V-p-\eta zp) \\ &\quad - (\mathbf{1}_{V-p>0} - \mathbf{1}_{V-p>0,A})\eta(V-(1-z)p) \\ &\quad - \mathbf{1}_{V-p<0}\eta(V-(1-z)p)^+, \\ \mathcal{S}_2^{\text{RB}} &= \mathbf{1}_{V-p>\eta zp,A}(V-p-\eta zp), \\ \mathcal{S}_2^{\text{RW}} &= \mathbf{1}_{V-p>\eta zp,A}(V-p-\eta zp) \\ &\quad - (\mathbf{1}_{V-p>\eta zp} - \mathbf{1}_{V-p>\eta zp,A})\eta(V-(1-z)p) \\ &\quad - \mathbf{1}_{V-p<\eta zp}\eta(V-(1-z)p)^+.\end{aligned}$$

These four equalities can be unified and expressed as

$$\begin{aligned}\mathcal{S}_2 &= \mathbf{1}_{V-p>\mathbf{1}_R\eta zp,A}(V-p-\eta zp) \\ &\quad - (\mathbf{1}_{V-p>\mathbf{1}_R\eta zp} - \mathbf{1}_{V-p>\mathbf{1}_R\eta zp,A})\mathbf{1}_W\eta(V-(1-z)p)^+ \\ &\quad - \mathbf{1}_{V-p<\mathbf{1}_R\eta zp}\mathbf{1}_W\eta(V-(1-z)p)^+, \quad (2)\end{aligned}$$

where, for  $y \in \{R, W\}$ ,  $\mathbf{1}_y = 1$  if the consumer is of type  $y$ , and  $\mathbf{1}_y = 0$  otherwise.

Equation (2) is a compact form that characterizes the cases of interest when analyzing a consumer's dynamic purchase under regret. The next lemma orders the relation between surpluses for each of these four types.

LEMMA 3. *For a given event  $A$ , the surpluses for consumers of type PB, PW, RB, and RW are ordered as follows for any realization of  $V$ :*

$$\mathcal{S}_2^{\text{RB}} \geq \mathcal{S}_2^{\text{PB}} \geq \mathcal{S}_2^{\text{PW}} \geq \mathcal{S}_2^{\text{RW}}.$$

Lemma 3 reveals two important points. First, an "always" consumer is never better off than a "buy" consumer because the former experiences regret even when not buying. Second, being a regret-reflecting type entails a higher threshold for spot purchases—to avoid the negative surplus when buying—but also makes regret more likely when not buying.

### 3.2. Period 1

We next consider the consumer's purchase decision in Period 1. A consumer who purchases in this period obtains the valuation of the product *less* the price paid and the disutility of regret should the product's valuation turn out to be lower than the price paid. Formally, his surplus is expressed as

$$\mathcal{S}_1 = V - (1-z)p - \beta(V - (1-z)p)^-. \quad (3)$$

We assume that the consumer's valuation  $V$  of the product is drawn from a range of values whose cumulative distribution function (CDF) is  $F(\cdot)$ . Also, we use  $\theta$  to denote a consumer's belief about the distribution such that the higher  $\theta$  is, the more likely the consumer is to believe that the product has a high valuation. Formally, such belief is defined as follows.

DEFINITION 1. A consumer's valuation  $V \in [l, h]$  is drawn from a family of distributions with parameter  $\theta$  and CDF  $F(\cdot | \theta)$ . Without loss of generality, let  $\theta \in [0, 1]$ . In addition, for all  $\theta \leq \theta'$ , let  $F(u | \theta) \geq F(u | \theta')$  for any given nonnegative  $u \in (l, h)$ .

From this definition it follows that a consumer's belief about the valuation of a product is increasing in  $\theta$  in the sense of first-order stochastic dominance.

In Period 1, the consumer has an anticipation of his Period 2 type. Let this anticipation be  $x \in \{\text{PB, PW, RB, RW}\}$ . To address the trade-off regarding whether or not to buy forward, the consumer compares the expected surplus from purchasing in Period 1 with the one from waiting until Period 2. This difference is formally expressed as

$$\mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^x], \quad (4)$$

where  $\mathcal{S}_2^x$  is as described in Lemma 2. Therefore, the consumer buys forward if (4) is positive but otherwise delays the purchase decision. The following proposition describes the consumer's purchase decision in Period 1.

**PROPOSITION 1.** *For a given probability  $\phi$  and a consumer with valuation distribution  $F(\cdot | \theta)$ , there exist*

$$\underline{\theta}_{RW} < \underline{\theta}_{PW} < \underline{\theta}_{PB} < \underline{\theta}_{RB}$$

such that the following statements hold.

- (i) *Regardless of type, the consumer will wait until Period 2 if  $\theta \leq \underline{\theta}_{RW}$  or will purchase in Period 1 if  $\theta \geq \underline{\theta}_{RB}$ .*
- (ii) *A type- $x$  consumer will purchase in Period 1 if  $\theta \geq \underline{\theta}_x$  but will otherwise wait until Period 2.*

Proposition 1 illustrates how a consumer's decision in Period 1 depends on his belief about the product's valuation and his anticipation of his type in Period 2. If he expects the product to have a sufficiently high valuation, then he will buy forward regardless of his anticipation of his Period 2 type; similarly, if he expects the product to have a sufficiently low valuation, then he will delay the purchase decision. On the other hand, if he expects the product to have a "moderate" valuation, then the consumer's decision actually depends on his anticipation of his Period 2 type: for each type there exists a unique threshold level such that once the consumer's belief about the valuation distribution exceeds this threshold, he would purchase in Period 1, but would otherwise wait until Period 2. In particular, given that  $\underline{\theta}_{RW} \leq \underline{\theta}_{PW} \leq \underline{\theta}_{PB} \leq \underline{\theta}_{RB}$ , a consumer who sees himself as an "always" type in Period 2 is more likely to buy forward than one who sees himself as a "buy" type. The corollary that follows illustrates how the intensity of consumer regret affects the purchase decision.

**COROLLARY 1.** *For a given  $\theta, \phi \in (0, 1)$ , we have that  $\mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^x]$  is increasing in  $\eta$  and decreasing in  $\beta$  for  $x \in \{PB, PW, RB, RW\}$ .*

Corollary 1 illustrates a direct and intuitive consequence from the definition of regret in our model, that if a consumer would regret more owing to *buyer's* regret, then he is more likely to buy on the spot, whereas if he would regret more owing to *hesitater's* regret, then he is more likely to buy forward. Simonson (1992) suggests that consumers who anticipate

how they would feel if they made the wrong move (such as not buying forward) are more likely to purchase a currently available item on sale than to wait for a better sale. This corresponds to the first part of our result. Furthermore, the second part of our result predicts that consumers who anticipate how they would feel if they made the wrong move (such as buying early) are more likely to wait.

### 3.3. Type Inconsistency

Zeelenberg (1999a) points out that, in addition to acknowledging the existence of consumers' anticipated regret, it is important to assess how accurate this anticipation is. To reflect this aspect, we consider the case where a consumer in Period 1 has an incorrect anticipation of his actual Period 2 type. Specifically, we define a *type-inconsistent* consumer as one whose anticipation of his future type differs from the actual one; in contrast, a *type-consistent* consumer is one whose anticipation of his future type matches the actual one.

Because of the potentially optimistic bias in self-prediction (Armor and Taylor 1998), consumers might suppose their future selves to be better aligned—that is, in our setting, more likely to be a pragmatic and "buy" type than a regret-reflecting and "always" type. There is a related stream of literature that studies possible sources of error in the prediction of emotions (for a review, see Wilson and Gilbert 2003). Our model attempts to formalize these issues in the context of regret, and it is the first to address the consequences of incorrect anticipation of one's future type in a dynamic purchasing context. Consider a consumer in Period 1 who anticipates his Period 2 type to be  $x'$  although his actual type turns out to be  $x$ , where  $x, x' \in \{PB, PW, RB, RW\}$ , and define his corresponding surplus as  $\mathcal{S}^{x',x}$ . Then, given his actual type  $x$ , it follows that the consumer is never worse off being type consistent. Formally, this translates into

$$\mathbb{E}_{V,A}[\mathcal{S}^{x,x} - \mathcal{S}^{x',x}] \geq 0. \quad (5)$$

Denote  $\Delta \mathcal{S}^x = \mathbb{E}_{V,A}[\mathcal{S}^{x,x} - \mathcal{S}^{x',x}]$  as the difference in expected surplus between a type-consistent consumer and a type-inconsistent one. The next corollary shows how this difference depends on consumer's type  $x$ .

**COROLLARY 2.** *If the consumer's type inconsistency leads to a different decision, such that the consumer should have forward bought, but does not, then*

$$\Delta \mathcal{S}^{\text{RW}} < \Delta \mathcal{S}^{\text{PW}} < \Delta \mathcal{S}^{\text{PB}} < \Delta \mathcal{S}^{\text{RB}};$$

*whereas if the type inconsistency leads to a different decision, such that the consumer should have waited, but does not, then*

$$\Delta \mathcal{S}^{\text{RW}} > \Delta \mathcal{S}^{\text{PW}} > \Delta \mathcal{S}^{\text{PB}} > \Delta \mathcal{S}^{\text{RB}}.$$

When making a dynamic purchase decision as described in this paper, a consumer is uncertain about his valuation of the product; furthermore, he might have incorrect anticipation of his future type. Proposition 1 takes both phenomena into consideration and captures consumer decision procedures. In addition, the analysis in this section hones in on the second phenomenon and reveals the consequences of having an incorrect anticipation of the consumer's own future type.

## 4. Conclusions

Psychologists have long recognized the importance of regret in human decision making. However, the cognitive environments that psychologists consider are not typical of consumer behavior or of managerial settings in general. In particular, the dynamic aspects of consumer decisions under regret have been largely ignored. This paper aims to characterize such regret in a consumer dynamic purchase context.

Our paper makes two principal contributions. First, we show that the dynamics of time are essential to characterizing regret by formulating a parsimonious two-period model that captures the dynamics of regret in consumer behavior. A consumer might regret buying forward rather than waiting for better information, or he might regret delaying the purchase decision, thereby failing to ensure availability or a better price. Second, we model consumer types—in terms of both how regret affects their decisions and what triggers the regret—which in turn influence the consumer surplus. Moreover, given that a consumer might not accurately predict his future type (Zeelenberg 1999a, Wilson and Gilbert 2003), we study how type inconsistency influences decisions as well as emotions. We believe that our model provides a tractable basis for

future theoretical and empirical analysis of and applications involving consumer behavior and management. Possible directions include (i) a model that includes the use of strategic stockouts and early-order discounts to stimulate revenues, in part by achieving segmentation of customer classes; (ii) a model that takes into consideration the supply quantity decision under regret; (iii) an experimental investigation to quantify the absolute and relative magnitude of the different types of regret; and (iv) a model using non-linear forms of regret as in Bleichrodt et al. (2010). We leave these and further extensions to future work.

## Appendix A. Dynamic Purchase Under Regret and Rejoice

In this section, we introduce the “rejoice” concept into the model for the sake of completeness. According to Loomes and Sugden (1982), individuals experience rejoice when they have made the best decision. Analogously to our definition of  $\beta$  and  $\eta$  in §3, we define  $\rho_1$  and  $\rho_2$  as the intensity of consumer's rejoice in Periods 1 and 2, respectively. We first consider the consumer's spot purchase decision in Period 2. Lemma 4 is an extension of Lemmas 2 and 3.

**LEMMA 4.** *In Period 2, the surplus for consumers of type PB, PW, RB, and RW are as follows:*

$$\begin{aligned} \mathcal{S}_2^{\text{PB}} &= \mathbf{1}_{V-p>0,A}(V-p-\eta zp) + \rho_2((1-z)p-V)^+; \\ \mathcal{S}_2^{\text{PW}} &= \mathbf{1}_{V-p>0,A}(V-p-\eta zp) \\ &\quad - (\mathbf{1}_{V-p>0} - \mathbf{1}_{V-p>0,A})\eta(V-(1-z)p) \\ &\quad - \mathbf{1}_{V-p<0}\eta(V-(1-z)p)^+ + \rho_2((1-z)p-V)^+; \\ \mathcal{S}_2^{\text{RB}} &= \mathbf{1}_{V-p>\eta zp,A}(V-p-\eta zp) + \rho_2((1-z)p-V)^+; \\ \mathcal{S}_2^{\text{RW}} &= \mathbf{1}_{V-p>\eta zp,A}(V-p-\eta zp) \\ &\quad - (\mathbf{1}_{V-p>\eta zp} - \mathbf{1}_{V-p>\eta zp,A})\eta(V-(1-z)p) \\ &\quad - \mathbf{1}_{V-p<\eta zp}\eta(V-(1-z)p)^+ + \rho_2((1-z)p-V)^+. \end{aligned}$$

For a given  $A$  and any realization of  $V$ ,

$$\mathcal{S}_2^{\text{RB}} \leq \mathcal{S}_2^{\text{PB}} \leq \mathcal{S}_2^{\text{PW}} \leq \mathcal{S}_2^{\text{RW}}.$$

Now we turn to the consumer's forward purchase decision in Period 1. If he purchases in Period 1, then his corresponding surplus becomes

$$\begin{aligned} \mathcal{S}_1^{\text{P}} &= V - (1-z)p - \beta(V - (1-z)p)^- \\ &\quad + \rho_1(V - (1-z)p - \mathbf{1}_A(V-p)^+)^+, \\ \mathcal{S}_1^{\text{R}} &= V - (1-z)p - \beta(V - (1-z)p)^- \\ &\quad + \rho_1(V - (1-z)p - \mathbf{1}_{V>p+\eta zp,A}(V-p))^+. \end{aligned}$$

Note that, unlike surplus under regret only, a consumer's surplus in Period 1 under both regret and rejoice depends

on his Period 2 regret type, that is, on whether he is a pragmatic type or a regret-reflecting type. The next proposition is an extension of Proposition 1 that describes consumer's forward purchase decision in Period 1 under both regret and rejoice.

**PROPOSITION 2.** *For a given probability  $\phi$  and a consumer with valuation distribution  $F(\cdot | \theta)$ , there exist  $\theta_{RW} \leq \theta_{PW} \leq \theta_{PB} \leq \theta_{RB}$  such that the following statements hold.*

(i) *Regardless of his type, the consumer will wait until Period 2 if  $\theta \leq \theta_{RW}$  or will purchase in Period 1 if  $\theta \geq \theta_{RB}$ .*

(ii) *A type- $x$  consumer will purchase in Period 1 if  $\theta \geq \theta_x$  but will otherwise wait until Period 2.*

Under both regret and rejoice, a type-consistent consumer is—as in §3.3—no worse off than a type-inconsistent one; therefore, (5) continues to hold. The next corollary illustrates how the intensity of a consumer's regret and rejoice affects the purchase decision.

**COROLLARY 3.** *For a given  $\theta, \phi \in (0, 1)$ , we have that  $\mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^x]$  is increasing in  $\eta$  and  $\rho_1$  as well as decreasing in  $\beta$  and  $\rho_2$ .*

In short, the introduction of rejoice, though somewhat complicating consumers' surpluses, does not qualitatively change the results obtained under regret only. In particular, the consumer's purchase decision in Period 1 remains the same (Proposition 2), a type-consistent consumer is still better off, and the intensity of a consumer's regret affects his purchase decision in the same direction (Corollary 3).

## Appendix B. Proofs

**PROOF OF LEMMA 1.** The consumer will buy forward if and only if  $\mathbb{E}_V[V - (1 - z)p] \geq \mathbb{E}_{V,A}[\mathbf{1}_A(V - p)^+]$ . Given that  $V - p = (V - p)^+ - (p - V)^+$ , (1) follows directly. The expression for guaranteed availability follows from setting  $\phi = 1$ , and the expression for no forward purchase discount follows from setting  $z = 0$ .  $\square$

**PROOF OF LEMMA 2.** Following the definition of the four regret types, if  $V - p > 0$  and the product is available, then a consumer of type PB purchases but regrets the price difference  $zp$ ; if  $V - p < 0$  or the product is not available, this consumer neither purchases nor regrets. The expression for  $\mathcal{S}_2^{PB}$  follows. For a consumer of type RB, the surplus is the same as for PW except that the purchase threshold  $V - p > \eta zp$ . For a consumer of type PW, if  $V - p > 0$  and the product is available, then he purchases it but regrets the price difference  $zp$ ; if  $V - p < 0$  or the product is not available, this consumer does not purchase yet still regrets the forgone surplus  $(V - (1 - z)p)^+$ . The expression for  $\mathcal{S}_2^{PW}$  follows. For a consumer of type RW, the surplus is the same as for PW except that the purchase threshold  $V - p > \eta zp$ . This concludes the proof.  $\square$

**PROOF OF LEMMA 3.** Consider  $\mathbf{1}_A = 1$  and then  $\mathbf{1}_A = 0$ . Lemma 3 follows directly from Lemma 2.  $\square$

**PROOF OF PROPOSITION 1.** We first need to show that  $\mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^x]$  is nondecreasing in  $\theta$ , where  $x \in \{PB, PW, RB, RW\}$ . For a given  $A$ , it is straightforward that  $\mathcal{S}_1 - \mathcal{S}_2^x$  is nondecreasing in  $V$ . Let  $V$  and  $V'$  be the consumer's valuations drawn from two different families of distribution with parameters  $\theta$  and  $\theta'$ , respectively. By Definition 1, for  $\theta \leq \theta'$  we have  $V \leq_{st} V'$ . By the characterization of first-order stochastic dominance (Müller and Stoyan 2002),  $V \leq_{st} V'$  if and only if  $\mathbb{E}_V[\psi(V)] \leq \mathbb{E}_{V'}[\psi(V')]$ , where  $\psi(\cdot)$  is a nondecreasing function. Hence, for a given  $A$ ,  $\mathbb{E}_V[\mathcal{S}_1 - \mathcal{S}_2^x]$  is nondecreasing in  $\theta$ . Since  $\mathbb{E}_{V,A}[S_1 - S_2^x] = \phi \mathbb{E}_{V|\mathbf{1}_A=1}[S_1 - S_2^x] + (1 - \phi) \mathbb{E}_{V|\mathbf{1}_A=0}[S_1 - S_2^x]$ , it follows that  $\mathbb{E}_{V,A}[S_1 - S_2^x]$  is also nondecreasing in  $\theta$ . Then, at the boundaries, we have  $\mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^x | \theta = 1] > 0$  and  $\mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^x | \theta = 0] < 0$ .

On the other hand, from Lemma 2 it follows that, for any realized  $A$  and  $V$ ,

$$\mathcal{S}_1 - \mathcal{S}_2^{RW} \geq \mathcal{S}_1 - \mathcal{S}_2^{PW} \geq \mathcal{S}_1 - \mathcal{S}_2^{PB} \geq \mathcal{S}_1 - \mathcal{S}_2^{RB};$$

furthermore,

$$\begin{aligned} \mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^{RW}] &> \mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^{PW}] > \mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^{PB}] \\ &> \mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^{RB}]. \end{aligned}$$

Hence there exist  $0 \leq \theta_{RW} < \theta_{PW} < \theta_{PB} < \theta_{RB} \leq 1$  such that  $\mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^x] \leq 0$  when  $\theta \leq \theta_x$ , and  $\mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^x] > 0$  otherwise. This concludes the proof.  $\square$

**PROOF OF COROLLARY 1.** By Lemma 2, for a given  $x \in \{PB, PW, RB, RW\}$  we have that  $\mathbb{E}_{V,A}[\mathcal{S}_2^x]$  is decreasing in  $\eta$ . On the other hand, from (3) it follows that  $\mathbb{E}_{V,A}[\mathcal{S}_1]$  is decreasing in  $\beta$ . Therefore,  $\mathbb{E}_{V,A}[\mathcal{S}_1 - \mathcal{S}_2^x]$  is increasing in  $\eta$  and decreasing in  $\beta$ .  $\square$

**PROOF OF COROLLARY 2.** If the difference in  $x'$  and  $x$  leads to a different decision, such that the consumer should buy forward but does not, then  $\mathbb{E}_{V,A}[\mathcal{S}^{x',x}] = \mathbb{E}_{V,A}[\mathcal{S}_2^x]$ , and  $\mathbb{E}_{V,A}[\mathcal{S}^{x,x}] = \mathbb{E}_{V,A}[\mathcal{S}_1]$ . Therefore, by Lemma 3,  $\mathbb{E}_{V,A}[\mathcal{S}^{x,x} - \mathcal{S}^{x',x}]$  becomes smallest when a consumer is of type RB, and greatest when a consumer is of type RW. On the other hand, if the difference in  $x'$  and  $x$  leads to a different decision, such that the consumer should wait but does not, then  $\mathbb{E}_{V,A}[\mathcal{S}^{x',x}] = \mathbb{E}_{V,A}[\mathcal{S}_1]$ , and  $\mathbb{E}_{V,A}[\mathcal{S}^{x,x}] = \mathbb{E}_{V,A}[\mathcal{S}_2^x]$ . Therefore, by Lemma 3,  $\mathbb{E}_{V,A}[\mathcal{S}^{x,x} - \mathcal{S}^{x',x}]$  becomes smallest when the consumer is of type RW, and greatest when the consumer is of type RB.  $\square$

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