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The Dark Side of Variety: An Economic Model of Choice Overload

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Abstract

Choice Overload is a phenomenon well studied in psychology. It goes against the classical "more is better" dogma and describes the behavior of an agent when presented with too many options, in which instance an agent may either experience a decrease in satisfaction or end up deferring the choice all together. The standard Utility Maximization model of economics, however, largely follows the classical dogma and is unable to accommodate the behaviors of Choice Overload. This paper seeks to offer two possible economic models for Choice Overload based on the two mechanisms put forward by the psychological literature: search cost and cost of anticipated regret.

1. INTRODUCTION

It is a common, sometimes daily, occurrence to walk into a supermarket and see aisles upon aisles of different product options. Twenty four types of olive oil. Fifteen types of milk. Fifty types of ice cream. This all comes from the belief that "more is better," particularly when it comes to having options. This belief then pushes suppliers to offer more variety in hopes that it will attract more customers and increase sales. Even beyond product variety, having more options is generally looked upon favorably as many people tend to go for choices that "leave their options open".

This is a belief that seems to be supported by more than the shelving habits of the local grocery store. One often finds that in studies of psychological wellness and marketing strategy, it is shown that the practice of personal choice has various positive effects. One study finds that the provision of choice can increase intrinsic motivation and perceived confidence, as children of autonomy-oriented grade school teachers reported more self-motivation and higher self-esteem than the children of more control-oriented teachers (Deci, 1981). Another study finds that having the ability to choose for oneself can increase task performance, as nursing home patients that are allowed more choice in their life show greater "alertness, active participation, and a general sense of well-being" (Langer & Rodin, 1976). Even if a person does not actually have more agency to choose, just the illusion of choice is enough to incite positive effects. The unwarranted illusion of choice has been associated with greater confidence (Langer, 1975) and even "the ability to care about others, the ability to be happy or contented, and the ability to engage in productive and creative work" (Taylor & Brown, 1988). Some research has even shown that when people and animals feel like their ability to choose is taken away with regard to impending reinforcements, severely negative consequences can result including distractibility, ulcers, or death (Lefcourt, 1973). Clearly this last example features instances of choice that are much more extreme than deciding what kind of ice cream to buy, but it still indicates the importance of choice.

From studies such as these, a common notion has been developed saying that it is always better to have more options and that variety is always a virtue. Why then do a plethora of marketing studies find that there are benefits from a reduction of variety in stores? In response to retailers' reluctance to reduce stock even in response to declining demand for fear of attracting fewer customers, one study researched how consumers perceive retail assortment and found that a reduction of specifically low-demand items does not significantly affect assortment perception (Broniarczyk et al, 1998). Other studies go further in showing how having more variety on store shelves may increase attractiveness to customers with diminishing returns (Roberts & Lattin, 1991) and how a larger product line may in some cases decrease the likelihood that that brand is chosen (Draganska & Jain, 2005). Still other marketing research papers talk about a necessary balance between "perceived assortment variety" and "perceived inter-item complexity", implying that there is an upper bound to the benefits of variety (Kahn, Weingarten, & Townsend, 2013).

The conflicting results of previous psychological studies that have praised the prospect of choice and marketing studies that warn of the dangers of too much variety have caused psychologists to go back and research in more detail the effects of varying levels of choice. From this research, several psychological studies have subsequently concluded that more options may not always lead to better results. One study found that when college students had to select soft drink flavors from a given set of options, satisfaction with their choice did not differ depending on the size of the choice set (Reibstein, Youngblood, & Fromkin, 1975). Others have indicated that having a choice set that is too large can actually lead to a decrease in satisfaction. Barry Schwartz, a psychology professor at Swarthmore College, wrote a famous book titled The Paradox of Choice: Why More Is Less that laments the gratuity of options not only in stores but also in life as people struggle to balance "career, family, and individual needs," and suggests that self-limiting one's choices can lead to greater satisfaction with those choices (Schwartz, 2004). Even the act of choosing has been shown to have its limits in its positive effects. One study found that participants who were tasked with making more decisions experienced "less physical stamina, reduced persistence in the face of failure, more procrastination, and less quality and quantity of arithmetic calculations" (Vohs et al, 2008). This phenomenon has been titled Choice Overload, and it refers to a collection of behaviors that can arise from engaging with too much variety and choice including unhappiness, decision fatigue, choosing a default option, and deferring the choice all together (that is, choosing not to choose). Recently, psychologists have moved on from simply proving the existence of Choice Overload to trying to find its specifications and limits. A meta-analysis conducted in 2014 collected all such research and concluded that whether or not Choice Overload is prompted depends on "choice set complexity, decision task difficulty, preference uncertainty, and decision goal" (Chernev, Böckenholt, & Goodman, 2014).

To talk more specifically about Choice Overload in a consumer context, this paper draws inspiration from what is probably the most famous instance of research on Choice Overload: the jam study by Sheena S. Iyengar and Mark R. Lepper in 2000. Iyengar and Lepper set up a tasting booth to sell jam in a grocery store known for its variety of offerings and its established tasting booth culture. Over the course of two 5-hour periods on two Saturdays, they observed 754 shoppers and their consumption behavior. In one period, they displayed 6 jams (the limited set) while in the other period they displayed 24 jams (the extensive set). Iyengar and Lepper had experimenters clandestinely monitor the tasting booth to see what percent of passing customers stopped to taste the jams and then what percentage of those tasters ended up actually purchasing some jam. Following the common belief that "more is better", 60% of passing customers (145 of 240) stopped at the extensive jam display while only 40% of passing customers (104 of 260) stopped at the limited jam display. The purchasing behavior, however, seem to support instead the concept of Choice Overload. The limited display showed 30% (31 of 104) of the tasters ended up buying some jam while only 3% (4 of 145) ended up buy jam after stopping at the extensive display. Having the extensive set to choose from seemed to cause consumers to more often defer their choice. Surprisingly, this result demonstrates that though people seem initially attracted to greater variety, having more options may not always lead to a better outcome, in this case more revenue for the booth.

The same paper by Iyengar and Lepper includes another study that tests how a varying amount of options can affect the consumer's satisfaction with their choice. They took 134 chocolate-loving Columbia University students and asked them to choose some chocolate from a set of options. One group of subjects was able to choose a piece of chocolate from 6 options and the other group could choose a piece of chocolate from 30 options. A control group was simply given a piece of chocolate to eat. Afterwards, the experimenters asked the subjects to rate how tasty, enjoyable, and satisfying the chocolate was on a scale of 1 to 7, which was then combined into a composite score of the subject's overall satisfaction with their chosen piece of chocolate. The results show a similar pattern to the one in the jam experiment. There was a statistically significant difference in the rated satisfaction levels, with subjects who chose from the limited set showing an average rating of 6.28 and subjects who chose from the extensive set showing an average rating of 5.46. Both choice groups, however, showed more satisfaction with the chocolate than did the control group. This indicates that there is some utility to be gained from getting a choice, but at a certain point, the process of choosing begins to hinder the satisfaction of the experience.

These experiments imply two important findings. First, though there is some utility in variety, at some point the process of choosing from too many options begins to decrease satisfaction from that choice. Second, having too many options may at some point become preventative, making the consumer defer the choice for a later time.

2. DIFFERENCE FROM STANDARD ECONOMIC THEORY

Despite multiple studies showing that choice overload is a set pattern of human behavior, particularly in regards to consumption, standard economic theory fails to be able to explain it. In the standard model, there exists a set of all possible alternatives, called a *domain*, but agents choose from a non-empty subset of available alternatives, called a *menu*, which will be represented as B. For the sake of both simplicity and practicality, menus under consideration in this paper can be taken to be *finite menus*, menus with a finite amount of items. The standard model assumes that agents have a utility function. A *utility function* is a function that assigns a utility value to every item in a menu. The *choice* that a subject makes is the item(s) that the subject selects from the menu B, denoted $C(B)$. Formally, it is presumed that an agent faces a certain menu multiple times and each time the agent picks one item from the menu, but that chosen item may not always be the same. For instance, considering a menu $B = \{a, b\}$, they could choose options a sometimes and option b at other times, making the choice from the menu including those two alternatives equal to $C(B) = \{a, b\}$. In other cases, the agent may always choose b over a, in which case $C(B) = \{b\}$. $C(B)$ is the subset of B consisting of the alternatives that the agent is observed to choose. The way that subjects choose which items to select is by following their utility function. Thus the choice of the standard model is

$$C(B) = \underset{a \in B}{argmax}\, U(a)$$

In the standard model, *C(B)* is the set of elements in the menu that maximize the utility function, hence why this model is also called the Utility Maximization model. Since *C(B)* is always predetermined for a given menu via an agent's utility function, it can be said that the utility of the menu as a whole is also predetermined by the utility of the alternatives in *C(B)*. The value of a menu to an agent is defined by the maximum utility they can achieve from the menu through their choices. This value of a menu defines its *value function*:

$$V(B) = \max_{a \in B} U(a),$$

where *V(B)* is defined by the maximum value of *U(a)* where *a* is any item, or *element*, in menu *B*. As discussed in Section 2, consumers experience a certain level of satisfaction with their choice and with their experience when making a purchase. This is the natural interpretation of asking about one's value function.

Given this standard model, two propositions are presented as key properties.

The first proposition states that larger menus yield higher satisfaction.

Proposition 1 [Monotonicity]: *For any menu B,B', if* $B \subset B'$ *then* $U(B) \leq U(B')$.

Proof: If $B \subset B'$, then the maximizer of U in B lies in *B'* as well. Therefore, the maximizer in *B'* has to be at least as good as the maximizer in *B*. That is, $\max_{a \in B} U(a) \leq \max_{a \in B'} U(a)$. Thus $U(B) \leq U(B')$. •

The intuition for the proof is as follows: If a menu *B'* is comprised of menu *B* plus some additional elements, then those new elements can have utilities higher, lower, or equivalent to the element with the maximum utility in *B*. If lower or equivalent, the maximum utility in the new set stays the same. If higher, however, this new element becomes the new maximum utility of the menu. Thus, the value of the maximum utility element of the new menu can only stay the same or increase by adding more elements. Putting this into different yet equivalent words, the utility of a menu can only stay the same or increase by adding more elements, since the utility of a menu in the standard model is the same thing as the value of the maximum utility element of that menu.

This implication of the standard model is not directly testable, because utility is not directly observable. If we follow the psychologists and take their measures of satisfaction as a measure of utility, however, then utility can then be treated as an observable object. It should be noted that this is a practice of psychology since economists do not measure utility and instead almost exclusively generate conclusions based on observed choices, making the prior assumption non-standard.

While the first proposition focuses on the satisfaction gained from a choice, the second proposition questions whether a choice should be made at all; in other words, deferral. In order to talk about deferral of choice, that behavior must first be defined formally. Informally, *deferral* is defined as the decision to not make a choice at the present time. Formally, fix an alternative, represented as "*o*", and interpret it as the agent's *outside option*. For example, customers at a restaurant can either choose an item from the menu or they can choose not to choose and leave the restaurant. In this case, leaving the restaurant is the outside option, which is equivalent to the customer choosing deferral and refusing to make a choice.

The second proposition states that if a non-deferral choice was chosen in one menu, adding more options to that menu will not result in the agent now choosing to defer the choice.

Proposition 2 [Independence of Irrelevant Alternatives]: *For any menu B, B' such that* $o \in B \subset B'$, $if\ o \notin C(B)\ then\ o \notin C(B')$.

Proof: Since menus are finite, there always exists a maximizer. Therefore, if $o \notin C(B)$, there must exist some other alternative $a \in B$ such that $a \in C(B)$. In particular $U(o) < U(a)$. Thus, in the larger menu *B'*, there still exists the alternative *a*, so *o* can never maximize utility and $o \notin C(B')$. •

The intuition for this proof is as follows: If an element *c* is chosen from menu *B*, and deferral is not chosen from *B*, that must mean that *c* has the maximum utility of all elements in *B* and it has a greater utility than deferral, by nature of Utility Maximization. Then, if *B'* is a larger menu made from adding a few more elements onto *B*, then the maximum utility of *B'* can only be larger than or equal to the maximum utility of *B* (see proof for Proposition 1). This necessitates that the utility of deferral is still less than the maximum utility of *B'*, which means that it cannot be chosen within the Utility Maximization model.

Another way of proving Proposition 2 uses a well-known property of Utility Maximization: *Sen's Alpha*. Sen's Alpha more generally states the independence of irrelevant alternatives (IIA) which says that if *a* is chosen from a big set *B'*, then it must also be chosen from any small set $B \subset B'$ that contains *a* (Sen, 1971).

Definition [Sen's Alpha]: *C satisfies Sen's α if for any pair of menus B, B' and alternative a such that* $a \in B \subset B'$, *if* $a \in C(B')\ then\ a \in C(B)$.

Alternative Proof of Proposition 2: Observe that if the default option is chosen in the big menu, the default option must also be chosen in the small menu. Then if *o* is not chosen in the small menu, it cannot be chosen in the big menu. •

These propositions are implied by the Utility Maximization model, thus if people behaved according to the standard model of economics, observed human behavior would show the patterns described in Propositions 1 and 2. In fact, these two propositions support the aforementioned common belief that having more options is always a good thing, which is why grocery stores will dedicate entire aisles to different types of potato chips and peanut butter companies will offer more than 12 types of peanut butter. At first glance, it indeed seems like real world actions follow from the conclusions of these two propositions, but as has already been shown, that simply is not the case.

Many studies of choice psychology demonstrate that these testable implications arising from the standard model and described in the propositions above are violated in real life. Increasing the size of a menu can lead to less satisfaction with both the process of choosing and with the eventually chosen item, and once increased to a certain degree, the size of a menu can become so daunting that the agent prefers not to make a choice and defers their choice even though they would make a choice with a smaller menu. This difference between the standard model and observed behavior stems from the assumption that in Utility Maximization, the agent is able to analyze and compare alternatives without any cost. Once a menu is presented, the agent already knows their utility function and can use that to effortlessly and instantly compare all the options to figure out which alternative is the maximizer. This kind of agent would walk into the potato chip aisle and leave it one second later with the type of chips that they know will give them the highest utility. Does this really sound like real life? No, in fact, far from it. Whether it's in the grocery store or in the middle of the night staring into a fridge for far too long, making choices requires time and effort. Without this cost of decision making, a real life consumer might indeed only stand to benefit from having more options available to them. Given that decision making does come with a cost, however, the costless Utility Maximization model cannot account for the observed behavior of choice overload. As such, an expansion of the standard model is required. Specifically, this new model must be able to accommodate Choice Overload behavior by violating the above propositions, thus instead having the properties of *nonmonotonicity* and *choice deferral*.

3. ALTERNATIVE MODELS WITH CHOICE OVERLOAD

The task of formulating a model to account for choice overload first requires that the exact mechanism of choice overload is understood. In fact, there are two main mechanisms through which choice overload is speculated to take effect in the psychological literature (Mills, Meltzer, & Clark, 1977; Payne, 1982; Schwartz, 2004). The first assumes that in smaller menus, the cost of evaluating all the available alternatives is not prohibitively high, so agents simply analyze them all and follow utility maximization. In menus that are larger than a certain threshold, however, the cost of evaluating all the alternatives such that maximization can occur is higher than the potential payoff from maximization. Thus, to decrease the cost of evaluation, the agent instead follows a satisficing behavior and uses some heuristic to make a quicker choice. *Satisficing* occurs when an agent selects an option not because it is the maximum utility choice, but because it meets a minimum utility goal. Prior economic research on search costs has focused on the subject of company incentives for obfuscation (Ellison & Wolitzky, 2012), but that subject addresses only consumers' knowledge of aspects of a certain number of products and does little to analyze the connection between the number of alternatives and consumers' purchasing behavior.

The second mechanism assumes that the agent doesn't fully understand their current preferences, such as when a consumer decides to buy a product they have never tried before, and they will only discover their preference with certainty after the choice is made. This allows for the possibility of regret if the agent finds out that they could have chosen an alternative that would've given them higher utility than the alternative they did choose. With larger menus, there is more chance that within the set of alternatives not chosen, there will be an item that would give higher utility than the item that was chosen, thus inducing greater regret and less net utility. There have been a handful of papers concerning regret in economic literature, starting with the basic regret model (Loomes & Sudgen, 1982) and going on to the MinMax Regret model (Hayashi, 2007), but these models have largely not been applied to Choice Overload and do not allow for special circumstances of Choice Overload demonstrated in psychological research, such as the possibility that larger menus can lead to higher utility under certain conditions (see Appendix for further discussion).

Some psychological studies have shown evidence of both mechanisms occurring in different circumstances (Mills, Meltzer, & Clark, 1977; Payne, 1982; Schwartz, 2004). As such, this paper will present two possible models of Choice Overload.

<u>Model 1: The Search Cost Model</u>

This model type describes the mechanism whereby the agent must incur some cost of decision making to evaluate all the alternatives and search for the utility maximizing one before they can make a choice. This search cost prevents the agent from being able consider a near infinite amount of alternatives, because eventually the cost of decision making becomes so great that it surpasses the maximum utility gained from the eventually chosen alternative. To begin to codify this mechanism of Choice Overload into an economic model, one must introduce this search cost into the process of choosing. Say that an agent believes with probability p that they will follow a utility function U_1, and with probability $1 - p$ they will follow a utility function U_2. When facing the menu, however, the agent doesn't know which of these is the true utility function. For instance, a consumer may not know what features of a car they value most when buying a car for the first time. Only after incurring the cost of searching the entire menu, $K(n)$, can they discover their utility function. Thus before incurring this cost, the agent must use these probabilities to form a belief about their expected maximum utility gain from conducting the search. In either scenario, if the agent makes a choice they will choose the maximizer of the menu, but that maximizer may differ depending on the utility function they follow. Thus, the cost of searching the menu is $K(n)$ and expected utility gain from searching B is

$$E(\max_{a\in B} U_i(a)) = p * \max_{a\in B} U_1(a) + (1-p) * \max_{a\in B} U_2(a)$$

It is assumed that the agent has no uncertainty about the value of the outside option, $U_1(o) = U_2(o) = 0$. The agent then compares the potential gain and the cost and decides if it's worth it to search the menu, find the maximum, and make the choice. If the cost of searching the menu is greater than the potential utility gain, the agent does not spend the effort and instead defers the choice. If the cost of searching the menu is less than the potential utility gain, then the agent still stands to gain from making a choice. The agent will then search the menu for the maximum, resulting in the agent becoming certain of their utility function. Thus their choice is defined as such for a menu B_n with n alternatives including the outside option, o, assuming that the search reveals a true utility function U_i

$$C(B_n) = \begin{cases} \arg\max_{a\in B_n} U_i(a) & \text{if } E(\max_{a\in B_n} U_i(a)) - K(n) > 0 \\ \{o\} & \text{if } E(\max_{a\in B_n} U_i(a)) - K(n) \le 0 \end{cases}$$

Making the value function, V, defined as follows

$$V(B_n) = \begin{cases} E(\max_{a\in B_n} U_i(a)) - K(n) & \text{if } E(\max_{a\in B_n} U_i(a)) - K(n) > 0 \\ 0 & \text{if } E(\max_{a\in B_n} U_i(a)) - K(n) \le 0 \end{cases}$$

It is easily seen that if the agent does make a choice, the resulting utility gain will be less than the utility gain they would experience in the standard Utility Maximization model. Thus, this Search Cost model is able to show how larger menus lead to less satisfaction (nonmonotonicity) and can possibly lead to deferral. In this way, the Search Cost model is able to accommodate the behavior of Choice Overload.

It should be noted that this model makes an important assumption about the nature of the agent, and that is that once the agent has begun searching through the entire menu, they must continue until all of the alternatives in the menu have been evaluated. Only then can the agent identify the maximizer and choose it. It may be the case, however, that an agent might begin analyzing the alternatives of a menu and when they reach a point where the cost of searching the menu becomes too great, rather than defer they may switch their method of decision making and become a satisficer instead of a maximizer. This would decrease the cost of searching the menu, making the decision once again worth making. In fact, psychologists say that each person is not necessarily only a maximizer nor only a satisficer. Every person has a certain inclination towards maximizing in any given situation. In one experiment analyzing, among other things, the effect of maximizing on choice overload, subjects had to take a questionnaire that would rate their maximization inclination on a 1 to 7 scale. Subjects who scored higher on this scale were more inclined to maximize when making a choice. The researchers defined "maximizers" to be those in the top third of the range (above 5.26/7) and "satisficers" to be those in the bottom third (below 3.49/7). Their results indicated that maximizers experience Choice Overload more strongly than do satisficers (Schwartz et al, 2002). This result supports the assumption of the Search Cost model that agents are strict maximizers. If the agents were strict satisficers, then the model would not apply since they do not experience Choice Overload, at least not as strongly. A model could be proposed that includes a variable to indicate an agent's inclination toward maximization, but for simplicity's sake the model presented here just assumes that agents are maximizers, thus they must search the whole menu before making a choice.

After some thought about the mechanism behind search cost, it quickly becomes apparent that there are many nuanced differences in the ways that "the cost of searching for the maximum" can be defined. When an agent evaluates alternatives in a menu, they must be able to do two things. First, they must be able to discover or assign a utility value for each item. For example, when buying a car, a consumer must take a look at all the features of a car before they can fully understand the utility that car will have for them. Second, they must have some way of comparing the utilities of alternatives to figure out a preference ranking for them. Here, the consumer is looking at the difference in features between two cars and deciding which car is better based on the features that they most value. After completing both of these processes, the consumer is finally able to determine which of the available cars is the best and make their choice.

In Utility Maximization, this is all assumed away such that it is done costlessly with the agent's utility function. In real life, however, both of these processes involve some cost, usually manifesting in the form of time or mental strain. The cost, however, can also be monetary if the agent, for example, pays a car expert to compare the cars for them or there is a fee associated with test driving the cars to discover how smoothly each one handles the road. In any case, the search cost can come from either of these two processes. Considering each of these two processes separately and independently, two different formulations of the search cost are possible.

The first formulation considers the case in which the cost of decision making comes from discovering the utility to be gained from each alternative and each utility discovery induces a cost *c*. Thus, for a menu with *n* items,

$$K(n) = c * n$$

In this formulation, the agent does not know the utility to be gained from each choice before the menu is searched. Once the utility of each element is known, the agent is able to implement their utility function to immediately and without cost discover which element would produce the highest gain in utility. This formulation assumes for simplicity that the cost to discover the utility of one element is the same for all elements in the menu. In the resulting value function equation, both the expected maximum utility in menu *B* and the cost of evaluating the utilities of the entire menu are increasing in *n* (See Proposition 1 for proof of why the expected maximum utility in menu *B* increases with *n*).

The second formulation considers the case in which the cost of decision making comes not from discovering the utility to be gained from each alternative, but rather from the act of comparing the utilities of each alternative to form a ranking and discover the maximum. Each comparison between two elements induces a cost of *c*. Thus, for a menu with *n* items,

$$K(n) = \left(c * \frac{n!}{2 * (n-2)!}\right)$$

In this formulation, the agent is able to know the utility of each element in a menu without cost, but the agent does not have a utility function that allows them to compare all elements simultaneously. The agent is only able to figure out which element has the highest utility by searching the entire menu and ranking every element. This formulation assumes that the agent only uses pair-wise comparison and that, for simplicity, each comparison induces an equivalent cost. Once the agent has ranked each element, they will discover the element of greatest utility. One can imagine this cost becoming quite large when each element has multiple aspects to consider, such as a consumer deciding between apartment listings of different types and in different neighborhoods. As before, in the resulting value function, both the expected maximum utility in menu *B* and the cost of ranking the utilities of the entire menu are increasing in *n*.

Example 1

Say an agent operates within a domain including the alternatives {*o, a, b*}. Suppose the agent is first faced with a two-item menu *B* = {*o, a*} which includes an alternative *a* and the option to defer the choice, *o*. The agent believes with probability 0.5 that they will experience U_1 and with probability 0.5 that they will experience U_2, defined as such

	U_1	U_2
o	0	0
a	6	4
b	6.5	3

Each element incurs a cost of 2 to discover its utility. Will this agent experience Choice Overload?

Solution:
The expected utility from searching is
$E(\max_{a\in B} U_i(a)) = (0.5*6) + (0.5*4) = 5,$
The cost of evaluating every item in *B* is
$K(n) = c*n = 2*2 = 4$

The expected maximum utility is more than the cost of evaluating the menu, 5 > 4, thus the agent does not experience choice overload and chooses the alternative that maximizes utility for the true utility function. In this case, whether that is U_1 or U_2 make no difference since the agent chooses *a* in both.

Now say that the agent faces a three-item menu *B'* = {*o, a, b*} which includes an alternatives *a* and *b* and the option to defer the choice, *o*. With the same utility discovery cost, will the agent now experience Choice Overload?

Solution:
The expected utility from searching is
$E(\max_{a\in B'} U_i(a)) = (0.5*6.5) + (0.5*4) = 5.25,$
The cost of evaluating every item in *B'* is
$K(n) = c*n = 2*3 = 6$
The expected maximum utility is less than the cost of evaluating the menu, 5.25 < 6, thus the agent does experience choice overload and chooses to defer.

Model 2: The Regret Aversion Model

In this model type, the cost of making a choice comes not from the effort or time required to make the choice, but is instead from the potential regret the agent may face after making the choice. In this case, the actual process of evaluating the items in a menu and figuring out which one is the potential maximum is assumed away to isolate the effect of the cost of regret. The agent doesn't have to incur any cost at the moment of the decision. After the choice is made, however, the agent may induce a cost in the form of regret. Regret occurs because the agent does not actually know their preferences until after they have made a choice. For example, in the case where a consumer is shopping for a computer, one option might have better battery life, but another option has a bigger screen size (which the consumer perceives as a positive thing). The consumer may not yet know which of these two factors they will end up valuing more. In one scenario, they may end up finding that they value battery life more and regret choosing the option with the bigger screen, but the reverse is also possible. One can see how increasing the amount of options or increasing the amount of option attributes would put the consumer at an even greater risk for finding out that another option would have been better, thus incurring greater regret. Eventually, the potential regret a decision could produce could become so great that the consumer experiences choice overload and defers the choice saying, "I'll come back to Best Buy another day."

To begin talking about regret formally, suppose that there are two periods, $t=0$ *or* 0^+. At $t=0$, the agent has a utility function U_0, and at $t=0^+$, the agent is either going to have the utility function U_1 or U_2. At $t=0$, the agent faces a menu and makes a choice, but at $t=0^+$, the agent potentially faces some regret about the choice in $t=0$.

To create a model that incorporates regret as a cost, the *MinMax Regret Model* is used as a base. (Hayashi, 2007) This base equation can then be expanded upon to incorporate regret as the cost of making a choice and accommodate Choice Overload behavior (For further description of the MinMax Regret model and a discussion on why the MinMax Regret model itself cannot serve as a comprehensive model of Choice Overload, please see the Appendix). Say that as an agent evaluates each alternative, they assume the worst possible outcome for each alternative. That is, just as is described in the MinMax Regret model, the agent sets the value of the alternative as the future utility it would have if it was chosen in the situation in which it would produce the most regret possible. This future utility is generated from the utility the agent would gain from the alternative itself and the cost of regret from having chosen that utility. Once the perceived future utility of each alternative is set, the agent then chooses the highest utility among them and the alternative that would produce it. In other words, this agent assumes the worst possible scenario and tries to hedge their bets by choosing the alternative that would do the best in the worst case scenario. If the second period turns out to be better than the worst case scenario, then the agent will experience a better situation than their perceived future utility. If they had chosen a different alternative, however, they would have experienced worse regret.

Defining the model formally, for a menu B with two possible future utility functions U_1, U_2 for alternative a, the agent's choice from the menu is defined as

$$C(B) = \underset{a\in B}{\operatorname{argmax}}\{\min\left\{U_1(a) - \lambda\left(\max_{a\in B} U_1(a) - U_1(a)\right), U_2(a) - \lambda\left(\max_{a\in B} U_2(a) - U_2(a)\right)\right\}\}$$

Thus the value function V is

$$V(B) = \max_{a\in B}\{\min\left\{U_1(a) - \lambda\left(\max_{a\in B} U_1(a) - U_1(a)\right), U_2(a) - \lambda\left(\max_{a\in B} U_2(a) - U_2(a)\right)\right\}\}$$

This formulation uses the general concept of the MinMax Regret model in a new way. Just as in the base regret model, the agent faces two possible utility functions. That is, each item has two possible utility values depending on which utility function is realized in the second period. In real life, an agent may face more than two possible utility functions, but two are used here for simplicity.

Let the following portion of the model representing the agent's possible Future Utilities from choosing alternative a be defined as such

$$FU(a|B) = \min\{U_1(a) - \lambda\left(\max_{a\in B} U_1(a) - U_1(a)\right), U_2(a) - \lambda\left(\max_{a\in B} U_2(a) - U_2(a)\right)\}$$

In this portion of the model, the agent evaluates the possible utility gain from choosing a in both circumstances. In either case, the agent would receive the utility gain of having a, $U(a)$, but they would suffer the regret given the realized utility function, $\max(U) - U(a)$. This regret comes from the potential utility gain lost if the maximizer of that utility function is not chosen (presumably because the agent chose the maximizer for the other possible utility function). The parameter λ is a measure of how strongly the agent experiences regret. If λ is low, then regret does not as strongly affect that agent's decision, while if λ is high, then the agent cares greatly about the possible regret from their choice. If $\lambda = 0$, then the agent does not experience regret and simply maximizes the lowest possible utility gained from each alternative. The agent then takes the lesser of the two possible future utilities and considers that value the predicted Future Utility from that alternative. Once the predicted Future Utilities are calculated for each alternative, the agent then chooses the alternative that provides the highest utility. This alternative becomes their choice, *C(B)*. In this way, the agent minimizes the potential regret should the worst case scenario occur.

The following example shows how this model matches the Choice Overload evidence by violating the standard model properties described in Proposition 1 and 2.

Example 1: Nonmonotonicity and Choice Deferral

Say that an agent with $\lambda = 1$ operates within a domain including an "outside option" representing deferral, *o*, and two alternatives *a* and *b*. The agent chooses first from an menu *B* comprised of just *a* and *o* Thus, *B* = {*o*, *a*}. To make this example more concrete, *o* can represent the apartment the agent currently lives in and *a* can represent the apartment they can move into. In State 1, U_1 is realized and in State 2, U_2 is realized. These utility functions and alternatives are defined by the following values:

	U_1	U_2
o	1	1
a	6	-1
b	-2	7

Given these values, the agent's perceived Future Utility from each alternative is as follows

$$FU(o|B) = \min\{1-(6-1), 1-(1-1)\} = -4$$
$$FU(a|B) = \min\{6-(6-6), -1-(1+1)\} = -3$$

With these Future Utility values, the agent's choice is then

$$C(\{o,a\}) = \underset{a\in B}{\operatorname{argmax}}\{FU(o|B), FU(a|B)\} = a$$

Since $FU(a|B) > FU(o|B)$, the agent chooses *a* from *B*. In this smaller menu, though alternative *a* poses some risk of regret if U_2 is realized (-1 – (1+1) = -3), the possible regret from not choosing *a* and instead choosing *o* followed by the realization of U_1 (1 – (6 – 1) = -4) is too great for the agent to bear. Thus the agent chose *a*. This could be a circumstance where apartment *a* has a much better price than apartment *o*, but the location of *a* might be a little worse than the agent's current apartment. Because the price is so much better, the agent decides to move and take the risk that they might regret downgrading their location.

Say that the agent then chooses from a menu *B'* comprised of *o*, *a*, and a new alternative *b* (that is, *B'* = {*o*, *a*, *b*}). Now the agent's perceived Future Utility from each alternative is as follows

$$FU(o|B') = \min\{1-(6-1), 1-(7-1)\} = -5$$
$$FU(a|B') = \min\{6-(6-6), -1-(7+1)\} = -9$$
$$FU(b|B') = \min\{-2-(6+2), 7-(7-7)\} = -10$$

With these Future Utility values, the agent's choice is then

$$C(\{o,a,b\}) = \underset{a\in B}{\operatorname{argmax}}\{FU(o|B), FU(a|B), FU(b|B)\} = o$$

Since $FU(o|B') > FU(a|B') > FU(b|B')$, the agent chooses *o* from *B'* and thus defers the decision by going with the outside option. Contrasting with the result of the smaller menu, in this larger menu both the regret from choosing *a* and realizing U_2 (-1 – (7 + 1) = -9) and the regret from choosing *b* and realizing U_1 (-2 – (6 + 2) = -10) are so great that the relatively small regret from choosing *o* while realizing either state (1 – (6 – 1) = -4 or 1 – (7 – 1) = -5) seems to be the more attractive option, thus pushing the agent to choose *o*, deferral. To put it in more qualitative terms, when the third option is added, the possible future utilities for the agent become much more extreme. If *a* and *b* are two different apartments the agent is considering moving into, the situation in this larger menu presents two risky options that counterbalance one another. This could be a circumstance in which one apartment has a great price and bad location and the other has a terrible price, but fantastic location. In the Regret Aversion model, the agent does not know if they value price or location more, and they will not find out until they make a decision between the two. With the added uncertainty from the extreme utilities and extreme potential regrets, the agent decides to not take the risk and instead chooses the safer option of going with what they already know. That is, they defer the choice and went with an outside option, a *default option*. In this case, that outside option is staying in the apartment the agent already lives in. This situation seems to mirror the thought processes of some real life consumers when faced with the need to choose from a large menu.

This example shows how the Regret Aversion model is able to accommodate the observed behaviors called Choice Overload. First, observe that the value of the menu was decreased by adding another alternative. Specifically, $V(B) = -3$ while $V(B') = -5$. This result is in line with Choice Overload's property of *nonmonotonicity*, thus violating Proposition 1. Second, observe that in the smaller menu, a non-deferral choice was selected, *a*, but in the larger menu, the agent opted instead for deferral*, o*. In this way, the result demonstrates the *choice deferral* behavior of Choice Overload and violates Proposition 2.

Beyond accommodating the possibility of Choice Overload, this model further follows the psychological evidence by allowing circumstances in which adding more options can increase the value of the menu and lead to results other than deferral. As discussed in Section 2, adding more options to a menu does not always result in Choice Overload. In fact, one study by Liat Hadar and Sanjay Sood (2014) observed how the occurrence of Choice Overload in larger menus is moderated by what they term "subjective knowledge," which is defined as how knowledgeable the agent feels about the alternatives from which they choose. They use the example of wine and soda. With wines, most people do not feel so knowledgeable about all the attributes of wine and their respective values. With soda, most people feel very knowledgeable about the difference in taste and thus their different personal values. Hadar and Sood showed that for domains in which the agent has a high level of subjective knowledge, the agent is more likely to make a choice when presented with a smaller menu, supporting the behavior of Choice Overload. For domains in which the agent has a low level of subjective knowledge, however, the agent is more likely to make a choice when presented with a larger menu, supporting the classical belief that "more is better". This observation could explain why there are many more options for wines than there are sodas.

The Regret Aversion model presented in this paper is able to accommodate instances of both. Specifically, the model can show instances of monotonicity and instances of nonmonotonicity, instances where the conclusion of Independence of Irrelevant Alternatives hold and instances of Choice Deferral. Interestingly, this model can also include some measure of subjective knowledge. If a person has a higher subjective knowledge about their alternatives, then the different possible values for any one alternative should be closer together.

That is, the agent is more certain about what the value of the alternative will be. Including subjective knowledge, however, is not the focus of this model and is left to future models for further development.

The previous example demonstrated Choice Overload. The following example demonstrates how the model can also allow for the classical belief of "more is better".

Example 2: An Instance of "More is Better"

Say that an agent with $\lambda = 1$ operates within a domain including an "outside option" representing deferral, *o*, and two alternatives *a* and *b*. The agent chooses first from an menu *B* comprised of just *a* and *o* Thus, *B* = {*o*, *a*}. To make this example more concrete, *o* can represent the apartment the agent currently lives in and *a* can represent the apartment they can move into. In State 1, U_1 is realized and in State 2, U_2 is realized. These utility functions and alternatives are defined by the following values:

	U_1	U_2
o	1	1
a	6	-1
b	2	4

Given these values, the agent's perceived Future Utility from each alternative is as follows

$$FU(o|B) = \min\{1 - (6 - 1), 1 - (1 - 1)\} = -4$$
$$FU(a|B) = \min\{6 - (6 - 6), -1 - (1 + 1)\} = -3$$

Since $FU(a|B) > FU(o|B)$, the agent chooses *a* from *B*.

Say that the agent then chooses from a menu *B'* comprised of *o*, *a*, and a new alternative *b* (that is, *B'* = {*o*, *a*, *b*}). Now the agent's perceived Future Utility from each alternative is as follows

$$FU(o|B') = \min\{1 - (6 - 1), 1 - (4 - 1)\} = -4$$
$$FU(a|B') = \min\{6 - (6 - 6), -1 - (4 + 1)\} = -6$$
$$FU(b|B') = \min\{2 - (6 - 2), 4 - (4 - 4)\} = -2$$

Since $FU(b|B') > FU(o|B') > FU(a|B')$, the agent chooses *b* from *B'*.

This example shows how the Regret Aversion model is able to accommodate the behaviors put forth in the standard economic model. First, observe that the value of the menu was increased by adding another alternative. Specifically, $V(B) = -3$ while $V(B') = -2$. This result is in line with the standard model's property of *monotonicity*, thus following Proposition 1. Second, observe that in the smaller menu, a non-deferral choice was selected, *a*, and in the larger menu, the agent simply selected another non-deferral alternative with a higher utility. In this way, the result demonstrates the *preference transitivity* behavior of standard Utility Maximization model and follows Proposition 2. This kind of flexibility allows the Regret Aversion model to more closely follow the psychological evidence than a model which always results in Choice Overload when more alternatives are added to a menu.

4. DISCUSSION

4. 1 Comparing Models

The above Search Cost models and the Regret Aversion model are just some of the possible formulations that could build on the standard Utility Maximization model of economics to explain the mechanism of Choice Overload. Given the (ironic) variety of possible formulations, is it possible to determine if one is more accurate to the observed data than another? Further research to explore this question might include field tests that measure the rate at which consumers turn to a default or deferral. Other experiments might include surveying consumers before, during, and after making a choice to see if the perceived cost occurred during the process of deciding or afterwards.

In fact, Iyengar and Lepper did something just like that in that same aforementioned study (2000). In the same study involving chocolate-loving Columbia University students choosing chocolate pieces from a set, Iyengar and Lepper sought to investigate which of the two mechanisms, search cost or regret, the subjects were thinking with as they experienced Choice Overload. To do this, they made a few assumptions. First, they assumed that those who suffer a search cost end up satisficing in the extensive choice scenario. Because they satisfice, they should report that they feel they are making a less informed decision and they should be more likely to opt for a default option. Additionally, they should feel less confident about their choice and predict lower satisfaction with their choice. That is, after they have chosen a chocolate and before they consume the piece they chose, they should predict that they might not be satisfied with their choice. Second, they assumed that those who suffer from the cost of regret might be more invested in the choice making process to avoid the potential regret, thus they should perceive the choice making process as more enjoyable yet also difficult and frustrating in the case of the extensive choice scenario.

Iyengar and Lepper then set up an experiment to gather the relevant metrics. In this experiment, the Columbia students would be divided into the limited, extensive, and control groups as described in Section 1. If they are in an experimental group, they would choose a piece of chocolate from the set. Then, before they eat the chocolate, they are asked to rate themselves and their choices on a 1 to 7 scale. These ratings included metrics such as how often they choose a default option, their satisfaction with their choice, how informed they felt making the choice, how much they enjoyed the choice making process, how difficult or frustrating they found the choice making process, and then after consumption, did they experience any choice regret?

The researchers found that there was no significant difference between the experimental groups in terms of confidence in their choice, anticipated satisfaction, how informed they felt, nor their tendency to choose a default. This all goes against the hypothesis that the subjects are thinking through the first mechanism of Choice Overload, search cost. The did, however, find that the extensive group did find the decision making process more enjoyable, difficult, and frustrating. These results support the hypothesis that the subjects thought through the second mechanism of Choice Overload, regret aversion.

Though these results seem to indicate that the “right” model is the Regret Aversion model, recall that there exist other studies that show support for the use of both Choice Overload mechanisms. Some studies in fact show that methods of decision making change with the size of a menu (Mills, Meltzer, & Clark, 1977; Payne, 1982). Others show that regret may lead to preferring smaller menus (Sarver, 2008; Schwartz, 2004). Additionally, it may be the case that the assumptions made by Iyengar and Lepper are the incorrect assumptions to make to parse out which mechanism is at play. For example, as has been discussed, it may be the case that when subjects suffer a search cost, they more often just defer the cost rather than switch to a satisficing model. Indeed it may be the case that both mechanisms operate depending on the situation. Further research is needed to see which mechanism occurs under what circumstances.

4.2 Applications

Two applications are presented here as instances of pricing and product offering that can be uniquely explained by the Choice Overload models presented in this paper.

The first application involves a seemingly obvious implication of both Choice Overload models: if a firm offers too many options, decrease the number of options and sales will increase. In fact, one firm did just that. Proctor & Gamble is a company that produces a shampoo called Head and Shoulders. Initially, Proctor & Gamble offered 26 different varieties of this shampoo, varying by factors such as scent and hair benefits. Seemingly following the advice of early marketing studies and psychological studies of Choice Overload, the company decided to decrease their product line to just 15 types of shampoo. The standard model would say that customers would then be less attracted to Head and Shoulders compared to other shampoo brands which offer a larger variety. Even Iyengar and Lepper's research would indicate that at least in terms of initial attractiveness, this decrease in variety could indeed harm the Head and Shoulder's brand perception. In fact, Proctor & Gamble experienced a 10% increase in sales after this change (Osnos, 1997). This matches the behavior as predicted by either model of Choice Overload presented here. Decreasing the number of alternatives decreased both the search cost and the possible regret from making a choice, thus turning some of the consumers who before would defer such a choice now into purchasing customers.

The second application involves the difference in pricing between convenience stores or drugstores, such as Walgreens, and supermarkets, such as Walmart. Because of the much larger variety of products that can be found at Walmart, everything obtainable in a Walgreens could also be found at Walmart. The standard model would then say that this greater variety offers greater value to the consumer. Thus, the supermarket should be able to charge a higher price for its products. In fact, most know very well that Walgreen's prices are much higher than Walmart prices, even for the same items. In fact, one study showed that for the same basket of products, Walgreens (WAG) charged roughly 40% more than did Walmart (WMT) (Peterson, 2014).

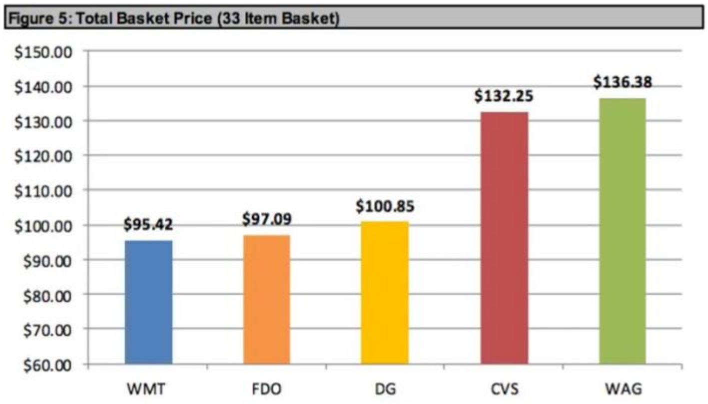

Figure 1. Source: Sterne Agee

One might argue that the higher prices of stores such as Walgreens are due to the convenience of access. They'd say customers are willing to pay higher prices to avoid travelling longer distances to get to the store. In fact, a study conducted on the drivers of pricing of staple foods in supermarkets versus small food stores found that prices of smaller stores did not significantly differ between stores that were "isolated," defined as stores that were greater than one mile away from the nearest supermarket, and those that were not (Caspi, 1997). This indicates that the higher prices of smaller stores with less variety, such as Walgreens, is not driven by a difference in travel convenience from the home to the store.

The higher prices, however, do seem consistent with the predicted behavior of the Choice Overload models. These models predict that the smaller variety of products found at Walgreens offers customers an easier shopping experience by lowering the cost of searching for the right choice and the cost of potential regret from realizing that the customer could have chosen a better alternative. At a larger store like Walmart, customers would have to spend more time searching for the right item, and they would be aware of the wider variety of alternatives causing them greater potential regret. Thus, the Choice Overload models predict that the smaller store with its easier shopping experience would offer the customers greater value and thus be able to charge higher prices. Intuitively, this result seems to match the observed pricing behavior. It is left to future research to demonstrate this more formally with demand functions that include Choice Overload.

5. CONCLUSION

The standard model of economics, namely Utility Maximization, is able to account for many generalized behaviors of human decision making, but it cannot account for the phenomenon known as Choice Overload. In this paper, two different models were introduced to try to add onto the standard model and find a way to include Choice Overload in the set of economically explained behaviors. They cover the two main mechanisms of Choice Overload put forth by the preceding psychological research, and further research is needed to discriminate in which situations each model applies and what other factors influence an agent's experience of Choice Overload. The Search Cost model and the Regret Aversion models are intended to at least be starting points on which further economic research on Choice Overload can build. These models help to understand how humans make choices, and how sometimes variety can have a dark side.

6. APPENDIX

The MinMax Regret Model

In the MinMax Regret Model model, (Hayashi, 2007) the regret from choosing item *a* from menu *B* is defined as

$$R(a|B) = \max\left\{ \max_{b\in B} u_1(b) - u_1(a), \quad \max_{b\in B} u_2(b) - u_2(a) \right\}$$

In this model, the agent may end up having preferences defined by U_1 or U_2. In both states, possible regret comes from the difference between the highest utility element in menu *B* and the utility of the chosen element *a*. The potential regret that the agent worries about is the scenario in which the regret from choosing *a* is higher, thus they take the maximum of the two scenario regrets and that becomes the perceived potential regret of the choice. The agent then makes a choice from the menu by minimizing the regret and choosing the item with the smallest perceived regret. The agent minimizes the maximum possible regret, hence why it is called the MinMax Regret model. For the reasons explained below, in this model an agent is either always worse off or indifferent from having larger menus when, in fact, larger menus can sometimes make the agent better off.

Difference Between Regret Models

If one were to use the MinMax Regret model for the two Regret Aversion model examples above, one would generate the same choice for Example 1 and a similar result for Example 2, with the agent indifferent between *a* and *b* instead of having a strict preference for *b*, so it might seem that the two models are nearly the same. A third example, however, can demonstrate at least one key difference between the two models.

Example 3: Difference of Regret Models

Say that an agent with $\lambda = 1$ operates within a domain including an "outside option" representing deferral, *o*, and two alternatives *a* and *b*. The agent chooses first from an menu *B* comprised of just *a* and *o* Thus, $B = \{o, a\}$. To make this example more concrete, *o* can represent the apartment the agent currently lives in and *a* can represent the apartment they can move into. In State 1, U_1 is realized and in State 2, U_2 is realized. These utility functions and alternatives are defined by the following values:

	U_1	U_2
o	1	1
a	2	2
b	3	3

Given these values, the agent's perceived Future Utility from each alternative is as follows

$$FU(o|B) = \min\{1-(2-1), 1-(2-1)\} = 0$$
$$FU(a|B) = \min\{2-(2-2), 2-(2-2)\} = 2$$

Since $\mathrm{FU(a|B)} > \mathrm{FU(o|B)}$, the agent chooses *a* from *B*.

Implementing the MinMax Regret model, the regret from each alternative is as follows

$$R(o|B) = \max\{2-1, 2-1\} = 1$$
$$R(a|B) = \max\{2-2, 2-2\} = 0$$

Minimizing the regret, the agent would still choose *a* from *B*.

Say that the agent then chooses from a menu *B'* comprised of *o*, *a*, and a new alternative *b* (that is, *B'* = {*o*, *a*, *b*}). Now the agent's perceived Future Utility from each alternative is as follows

$$FU(o|B') = \min\{1-(3-1), 1-(3-1)\} = -1$$
$$FU(a|B') = \min\{2-(3-2), 2-(3-2)\} = 1$$
$$FU(b|B') = \min\{3-(3-3), 3-(3-3)\} = 3$$

Since $FU(b|B') > FU(o|B') > FU(a|B')$, the agent chooses *b* from *B'*.

Implementing the MinMax Regret model, the regret from each alternative is as follows

$$R(o|B') = \max\{3-1, 3-1\} = 2$$
$$R(a|B') = \max\{3-2, 3-2\} = 1$$
$$R(b|B') = \max\{3-3, 3-3\} = 0$$

Minimizing the regret, the agent would again still choose *b* from *B'*.

There is an important difference here between the results of the two models of regret. While the MinMax Regret model is able to generate the same choices, it does not lead to the same monotonicity (or nonmonotonicity) results that the Regret Aversion model can accommodate. In the example above, the agent's utility is shown to increase when first choosing from *B* and then from *B'* using the Regret Aversion Model. In other words, the agent follows standard monotonicity behavior. Using the MinMax Regret model, the agent experiences no such gain in utility. In fact, the regret experienced by choosing from the two menus is the same, thus the agent is indifferent between choosing from the larger menu versus the smaller menu. This is neither monotonicity nor nonmonotonicity. In this way, the MinMax Regret model cannot demonstrate the same change in utility from differently sized menus, thus the two models are distinguished.

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