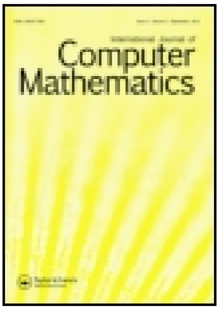

International Journal of Computer Mathematics
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gcom20

Numerical analysis of a time allocation model accounting for choice overload

Raúl G. Sanchis [a] , José-Manuel Rey [b] & Francisco Álvarez [c]
[a] Faculty of Economics and Business , Universidad Complutense de Madrid , Madrid , Spain
[b] Department of Economic Analysis , Universidad Complutense de Madrid , Madrid , Spain
[c] Department of Quantitative Economics , Universidad Complutense de Madrid , Madrid , Spain
Accepted author version posted online: 30 May 2013.Published online: 11 Jun 2013.

International Journal of Computer Mathematics, 2013
http://dx.doi.org/10.1080/00207160.2013.799667

Numerical analysis of a time allocation model accounting for choice overload

Raúl G. Sanchis[a], José-Manuel Rey[b]* and Francisco Álvarez[c]

[a]*Faculty of Economics and Business, Universidad Complutense de Madrid, Madrid, Spain;* [b]*Department of Economic Analysis, Universidad Complutense de Madrid, Madrid, Spain;* [c]*Department of Quantitative Economics, Universidad Complutense de Madrid, Madrid, Spain*

(*Received 23 October 2012; revised version received 25 January 2013; accepted 22 April 2013*)

The cost of time has been suggested as a factor associated with the choice overload problem. This term refers to the discomfort or paralysis experienced by individuals when facing a choice within a large set of alternatives, as it has been evidenced in experiments by behavioural and social psychologists. We introduce a rational model of time allocation to analyse how increasing the number of options of a given product may change consumer's allocation of time and in turn affect her welfare. Under some standard assumptions, the numerical analysis of the model reproduces two key experimental findings, namely choice paralysis – i.e. the choice problem is abandoned if the number of options is too large – and choice dissatisfaction – that is, the apparent paradox that increasing the number of considered options beyond certain limit, in turn choosing better, eventually diminishes welfare. The model analysis provides specific threshold values for the occurrence of both phenomena.

Keywords: time use; allocation of time; choice overload; paradox of choice; optimization; consumer behaviour

2010 AMS Subject Classifications: 65K99; 91B42; 91E99

1. Introduction

Western consumers face a significant number of options when making any choice in the market. Examples can be easily found practically in every domain of daily life in the West: a simple web search for a laptop produces hundreds of different product entries; shopping for a pair of jeans entails a deliberation among a surprisingly large number of different fits, waists, cuts, washes, zippers, etc.; finding your favourite salad dressing seems a daunting task considering the huge variety offered in a regular supermarket. Being a consumer in the market seems quite demanding in terms of choice.

Psychological research has revealed that such an explosion of choice may affect consumer's welfare in a way that is contrary to a basic principle of market culture, namely 'more choice implies more freedom which in turn implies more welfare'. According to Schwartz [11], this dogma is so deeply rooted in industrialized societies that in the end leads to a tyranny of choice paradoxically producing dissatisfaction rather than liberation. Schwartz suggested that beyond certain number of options more choice actually decreases satisfaction and termed this phenomenon the paradox

*Corresponding author. Email: j-man@ccee.ucm.es

of choice [12]. He also claimed the existence of a paralysis effect, i.e. decision makers that have to face a very high number of options eventually do not solve the choice problem, choosing not to choose. This intriguing idea has been supported by some experiments or field studies, in particular by Iyengar and Lepper [4]. The fact that enlarging the choice set may decrease the value of a welfare function apparently defies the logic of rational decision and entails interesting potential implications in theoretical microeconomics.

The idea that increasing the number of options in a choice problem entails adverse effects for the decision maker is called the choice overload hypothesis [10]. The choice overload hypothesis has attracted the attention of a variety of disciplines is social sciences, see e.g. [1,2,6,8,9]. Research in the last decade indicates that the psychological effects of 'too-much choice' are not universal. In fact, there is some controversy about the occurrence of choice overload and its specific effects [3,10]. Thus, it is considered that the negative effects of choice overload suggested in [4,11] may not appear in general but under specific circumstances. The state of the art now revolves around finding probable scenarios for choice overload, that is, to find out which conditions are necessary and/or sufficient for the choice overload hypothesis.

The cost of time has been implicitly considered as a contributing factor to the problems associated with choice overload. However, a formal model based on time use has not been proposed so far to address this issue. In this paper we introduce a simple time allocation model that gives account of the choice paralysis and the paradox of choice under standard conditions. The model can be numerically implemented for any specific choice problem provided that market data is available. Consumer search behaviour and product price structure are the basic inputs of the model. The main output of the numerical analysis is an optimal time distribution that provides the underlying structure of the rational solution of the choice problem. The analysis also yields as a by-product the number of product options that induce consumer paralysis or discomfort. The ability of our analysis to explain both paralysis and choice distress is exhibited by considering a naive case study of different types of consumers planning a tour around Europe. It is clear how to perform a similar analysis – *mutatis mutandis* – in any other choice problem with time use as the underlying resource.

The cost of effort when searching for the best seems a key factor for the appearance of adverse effects of choice overload – specifically, the paralysis effect and the paradox of choice. In a broad sense, this effort is probably measured in terms of the time detracted from other more rewarding activities. In this setting, our model provides some natural conditions for choice overload. First, consumers must seek to maximize their welfare in terms of the use of their time – this may be seen as a version of Schwartz's maximizers (vs. satisficiers) [12]. Second, search and decision time increases with the number of options at least at a constant rate, whereas benefits of considering more options increase but in a decreasing fashion. These are typical conditions in the choice situations that consumers face in the market. It turns out that the negative effects mentioned above arise with considerable ease. There are, however, specific situations – that can be considered atypical – in which more is always better. These are related with an extremely efficient search behaviour or with an excessive taste for shopping time. In our analysis, we consider both such typical and exceptional profiles of consumers to illustrate the boundary conditions within our model for the choice overload hypothesis.

2. The model

A consumer who makes any choice in the market implicitly decides about how to spend her total available mass of time (T) in three basic different uses of time: shopping time (employed in the search and decision about what to buy), working time and non-working time (devoted to leisure or consumption of goods at no expense, but not to shopping). The individual must fulfil the time constraints:

$$T_s + T_f + T_w = T, \quad T_s, T_f, T_w \geq 0, \tag{1}$$

where T_s is shopping time, T_w is working time and T_f is leisure or free time.

The consumer typically finds a large number of market options for every product. Let us focus on her decision about acquiring a single product among the many versions of the product offered in the market. Let N be the number of product options that she finds and inspects to make her buying decision. Her total expenditure is bounded from below by some quantity G which is clearly a function of the number of options N, that is $G = G(N)$. The consumption problem is thus subject to the budget constraint

$$G(N) \leq wT_w + V, \tag{2}$$

where w is the wage rate per unit of working time (T_w) and V is non-working income or savings. Since $G(N)$ represents the best deal for the searched product, it depends in a non-increasing fashion on the N options of the product checked by the consumer.

Since the best price decreases as the number of seen options increases, there is incentive to look for more options and in turn to spend more time searching in the market. On the other hand, searching for more options entails a minimum shopping time which typically depends on the number of options. Let $\tau = \tau(N)$ denote the minimum shopping time that is necessary to find and evaluate N versions of the product. The consumer problem must fulfil the time constraint

$$T_s \geq \tau(N). \tag{3}$$

Notice that the shopping time floor defined by $\tau(N)$ may depend on the search efficiency of the consumer, and also on the organization of the market of the product. In general, $\tau(N)$ is a non-decreasing function of N.

Under the standard assumption of rational behaviour, the consumer seeks to maximize her welfare. Since this depends on the way she decides to use her time, her welfare can be written as a function

$$U(T_s, T_f, T_w). \tag{4}$$

Therefore, the consumer choice problem is modelled as an optimization problem in which she determines the time distribution (T_s, T_f, T_w) that maximizes her welfare function (4) subject to constraints (1), (2) and (3).

3. Numerical analysis

The framework described above is very general and it can be adapted to any search-and-buy situation in a multi-option market environment. The ability of the model to address the choice overload problem is illustrated with a simple case study, based on the situation described below.

A student is planning a vacation tour around Europe (at least two-weeks long) during June, in three months. She decides to look for an organized trip on the internet. A simple web search like ‘organized trips to Europe’ produces thousands of pages with hundreds of entries each. So, even after filtering trip data in a suitable way, our student faces a choice problem with a huge number of versions for the product she is looking for. Furthermore, each travel that she finds feasible may require a significant amount of inspection time. Assume that she has got some small savings, say V, and that she can get extra money to buy the trip by working on weekends for a wage of w

per hour. All the money she earns is saved to pay for the trip. Since she is very busy during the week, her choice problem concerns weekend time only. She must decide how to allocate her total estimated weekend time T during the spring term, given that she must work, search for a good deal on the internet and enjoy herself the rest of the time.

Assume that the consumer's welfare is described in terms of time uses by a standard Cobb–Douglas function – in logarithmic form –, which is commonly used in economics (see e.g. [7,13]), namely

$$U(T_{\mathrm{s}}, T_{\mathrm{f}}, T_{\mathrm{w}}) = a_1 \log(T_{\mathrm{s}}) + a_2 \log(T_{\mathrm{f}}) + a_3 \log(T_{\mathrm{w}}), \tag{5}$$

where typically $a_i > 0$, for $i = 1, 2, 3$, T_{s} stands for time used to scrutinize trips, T_{f} is enjoyment time and T_{w} is working time.

3.1 *Data and methods*

In order to carry out the analysis, price estimates of the different product versions are needed to build the least-expenditure function $G(N)$ as a function of the number N of alternatives in the market. An enormous amount of data about tours around Europe can be obtained via an internet search. Our estimate of $G(N)$ is obtained by processing raw data from a very popular US travel website, one that provides a wealth of information about prices of many tours around the world.[1] Filtering by 'tours of two weeks length or more' we found 319 different products, and their corresponding prices are used to generate $G(N)$.

The function $G(N)$ is constructed using some resampling from the original data. The underlying idea is simple. Given a set of available prices, different consumers might perform their search in that set following different search rules. Even though all of them may be looking for, say, the lowest price, they might look at prices in different order because of different search engines or search strategies. Notice that, even though a search engine may efficiently arrange data in a suitable way, a consumer can actually look at the filtered data following many different sub-arrangements. We try to capture the behaviour of an average consumer by resampling a number of times, so that each resample represents a consumer's path search, and then averaging across those resamples.

Specifically, we proceed as follows. Let $\{p_1, \ldots, p_{\hat{N}}\}$ be the set of actual prices, where $\hat{N}$ is arbitrary. We resample from that set by taking random permutations. Let us denote the ith permutation by $\{p^i_{(1)}, \ldots, p^i_{(\hat{N})}\}$. Thus, the ith consumer perceives that the lowest price among the first N options that she searched is $g_i(N) := \min\{p^i_{(1)}, \ldots, p^i_{(\hat{N})}\}$, for all $N \in \{1, \ldots, \hat{N}\}$. We then take

$$G(N) := \frac{1}{I} \sum_i g_i(N),$$

where I is the number of permutations. For the final version we have carried 500 permutations.

Notice that as N increases, that is, when consumers have searched a large part of the dataset, all of them tend to agree on which is the lowest price of the sample. In the extreme case, $g_i(\hat{N}) = \min\{p_1, \ldots, p_{\hat{N}}\}$ regardless of the permutation index. However, at a time at which consumers have explored just a few prices, they might – and generally do – differ in their estimation on the lowest available price.

When processed as described above, our collected data on prices produces the graph of $G(N)$ that is represented in Figure 1.

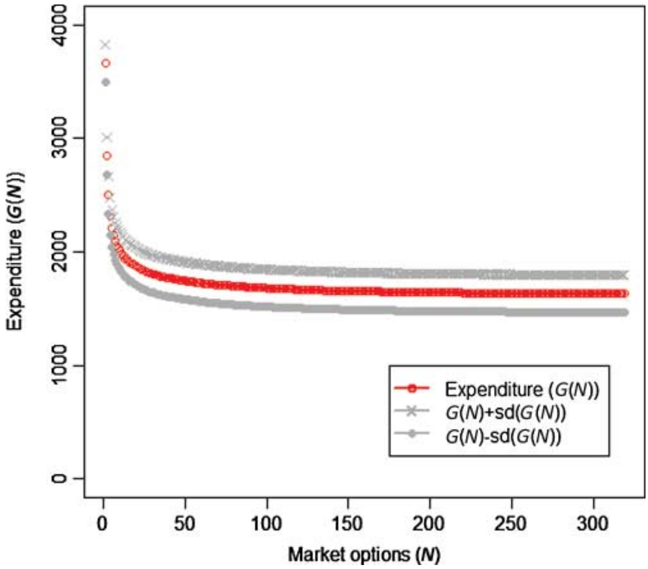

Figure 1. Expenditure $G(N)$ with the number of market options (N) (colour online only).

The function $\tau(N)$ defining the shopping time floor (3) is obtained using textbook assumptions in economic theory. Strictly speaking, it is a cost function that maps the number of searches into its cost in terms of time. It is usually assumed in economics that the marginal cost of an additional search either is constant or increases with the number of searches. A general structure of $\tau(N)$ that allows for both assumptions is a first order stochastic difference equation:

$$\tau(N) = \tau(N-1) + \varepsilon(N), \quad N = 1, 2, \ldots \tag{6}$$

starting from some initial condition $\tau(0)$ and being $\{\varepsilon(N)\}_N$ some random sequence. Clearly, the marginal cost of the Nth search is precisely $\varepsilon(N)$, and thus the referred assumptions are easily translated into assumptions on the probability law for that random sequence. First, we claim that a random nature for that marginal cost is fairly realistic. Second, it is also plausible that the marginal cost must be bounded from below by 0. Now, we model a constant marginal cost by taking for $\varepsilon(N)$ a probability distribution independent of N, whereas increasing marginal cost is modelled by considering a probability distribution whose expected value increases with N. We have used uniform distributions defined on some interval $[\underline{\varepsilon}, \bar{\varepsilon}]$ for the shock distribution. The initial value $\tau(0)$ is also uniformly distributed in some interval $[\underline{\tau}_0, \bar{\tau}_0]$ regardless of the marginal cost structure applied thereafter. Exploring alternative interval values as well as probability distributions produced no qualitative differences on the essential results, so we opted for the uniform distribution model for the sake of simplicity. In both cases, we generate a number of realizations the whole of sequence $\{\tau(N)\}_N$ and then we take the average sequence to be the search cost function of the problem. We have used 500 realizations for the final product.

Once the sequences $\{G(N)\}_N$ and $\{\tau(N)\}_N$ are computed, we continue with the optimization procedure. For a given set of parameter values (including V, w, T and parameters a_i's in the welfare function) and for each N we solve the maximization problem described in the previous section. As a numerical optimization method, we use the well-known Broyden–Fletcher–Goldfarb–Shanno method, usually denoted in the literature as BFGS [5]. Alternative methods show similar performance with regard to convergence and computation time.[2]

3.2 *Results and discussion*

3.2.1 *Description of cases*

To demonstrate the robustness of our numerical findings, we analysed many different choice problems that are obtained by varying the model inputs. It is particularly interesting to consider different consumer attitudes, regarding either search efficiency or sensitivity of welfare to time use. The following five cases illustrate this point.

Case #1: a consumer whose expected search-and-checking time per option is constant.

This case corresponds with that of a shopping time floor with constant marginal cost, as described in the previous section. Thus the individual spends a random time $\varepsilon(N)$ inspecting the Nth option which is independent of the number of options previously checked. We assumed that $\varepsilon(N)$ is uniformly distributed on the time interval $[0, 2]$, which amounts to spend one hour on average exploring each considered trip option. Equation (6) described in previous section produces a function $\tau(N)$ with a linear shape, whose graph can be seen in Figure 2 – labelled with 'tau'.

Case #2: a consumer whose expected search-and-checking time per option grows with the number of seen options.

In this case, the shopping time floor has increasing marginal cost. To explore the Nth option, the individual spends a random time $\varepsilon(N)$ whose expected value grows with the number of seen options. As explained above, this is modelled with an $\varepsilon(N)$ that follows a uniform distribution on an interval with increasing length with respect to N. In this exercise, we consider intervals whose length increases exponentially with N (Table 1). As a consequence, the expected time per option will also increase exponentially. The method in Equation (6) produces here a convex and increasing shape for the $\tau(N)$ function. The resulting curve is displayed in Figure 3 with label 'tau'. The convexity of the curve can be interpreted as a fatigue effect in the search activity.

Case #3: a consumer who dislikes shopping.

This case considers a significant variation in the features of the consumer of case #2, namely, her welfare is affected negatively with the shopping time. We thus assume that $a_1 < 0$ in this case (Table 1) so that her welfare function (5) is a decreasing function of T_s. We keep $a_2, a_3 > 0$ as in the cases #1 and #2. Also, wage rate is reduced by 40% with respect to cases #1 and #2. This will

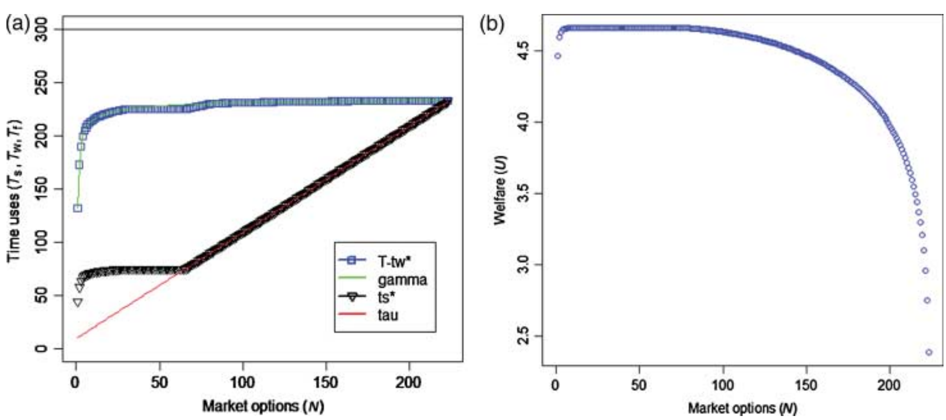

Figure 2. Optimal time allocation as a function of the number of options N (a) and welfare vs. N (b) for an individual whose expected search-and-checking time per option is constant (case #1 in Section 3.2.1) (colour online only).

Table 1. Parametrical values for the inputs and main outputs.

	Inputs										Outputs	
Case	T	w	V	a_1	a_2	a_3	$\underline{\tau}_0$	$\bar{\tau}_0$	$\underline{\varepsilon}$	$\bar{\varepsilon}$	$\bar{N}$	N^*
1	300	20	300	0.25	0.50	0.25	0	20	0	2	223	56
2	300	20	300	0.25	0.50	0.25	0	20	0	$2e^{(0.02N)}$	84	38
3	300	12	300	−0.05	0.50	0.25	0	20	0	$2e^{(0.02N)}$	74	7
4	300	20	300	0.95	0.65	−0.15	0	20	0	0.10	–	319
5	300	20	300	125	0.65	−0.15	0	20	0	$2e^{(0.02N)}$	84	84

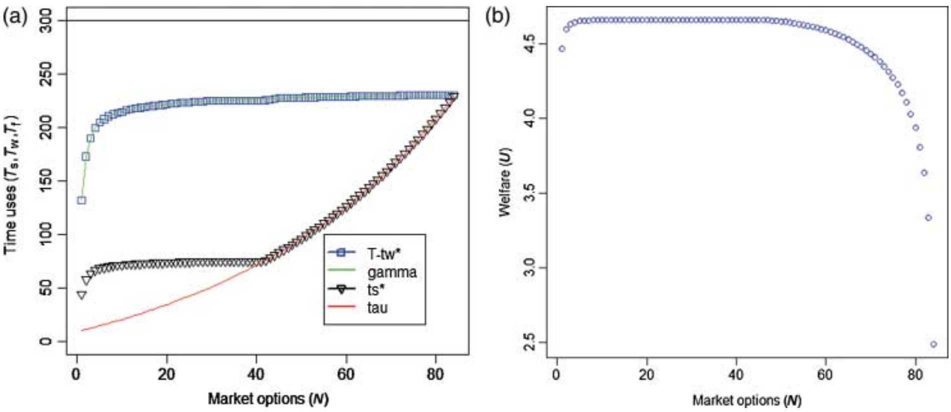

Figure 3. Optimal time allocation as a function of the number of options N (a) and welfare vs. N (b) for an individual whose expected search-and-checking time per option grows with N (case #2 in Section 3.2.1) (colour online only).

affect the individual's propension to work and in turn her optimal time distribution compared to the individual in case #2.

Case #4: a consumer who is very efficient in her search behaviour.

This case considers a consumer with a linear shopping time floor, as in case #1, but with a very efficient search behaviour, which amounts to a low value for the upper bound $\bar{\varepsilon}$ of the support of the distribution $\varepsilon(N)$. In particular, we considered a value for $\bar{\varepsilon}$ (see Table 1) such that the consumer spends about three minutes, on average, on each option. We assume here that $a_3 < 0$, so that more working time T_w implies less welfare. We also assume that $a_1 > a_2$, so the consumer is a sort of shopping lover, since she prefers some more shopping time rather than some more free time even when she is spending more time shopping than relaxing – up to a certain level, i.e. as long as $T_s/T_f < a_1/a_2$. The wage rate is as in cases #1 and #2.

Case #5: a consumer who does extremely like shopping time.

This is the case of an individual whose welfare is as in case #4, but with an extremely high value a_1 (see Table 1) so that she prefers some more shopping time rather than some more free time up to time ratio T_s/T_f disproportionately large (about 190 to 1, see Table 1). This makes this individual an extreme shopping lover. Her search behaviour is as in cases #2 and #3, so that $\tau(N)$ is convex and she experiences fatigue when checking more options. Wage rate is the same as that in cases #1, #2 and #4.

The values for the parameters in each case are summarized in Table 1.

The primary output of the model is the optimal time allocation for each number of options N. Table 1 shows also two key outputs of the model, $\bar{N}$ and N^*, related with the choice overload problem. Specifically, for a number of options N in the choice problem, $\bar{N}$ is the value for which the individual experiences choice paralysis, i.e. she decides not to choose; and N^* is the initial value for which the paradox of choice occurs, i.e. the decision-maker's welfare starts to decrease beyond N^*.

3.2.2 *Results*

Figures 2–6 summarize the model findings for cases #1, #2, #3, #4 and #5 described in Section 3.2.1. The shopping time floors, defined by $\tau(N)$, are displayed in red (with label ‘ tau’) in Figures 2(a), 3(a), 4(a), 5(a) and 6(a) on the left side – notice that $\tau(N)$ does not change in cases #2 and #3. It follows from Equation (2) that $T_w \geq \max\{0, (G(N) - V)/w\}$ which imposes a lower bound for the working time, or a time ceiling for the sum of times $T_s + T_f$, that is, $T_s + T_f \leq \gamma(N)$ for each N. The curves $\gamma(N) := \min\{T, T - (G(N) - V)/w\}$ are shown in green in Figures 2(a), 3(a), 4(a), 5(a) and 6(a) (with label ‘gamma’). Notice that the curve $\gamma(N)$ is the same in cases #1, #2, #4 and #5.

In each figure (a) on the left side, optimal time allocations versus the number of options are displayed as follows. For every number of options N, the black curve with triangles downwards and the blue curve with squares partition the total time T (which is 300 in our study) in the three time uses of the model: T_s is given by the distance from the x-axis to the black curve with triangles,

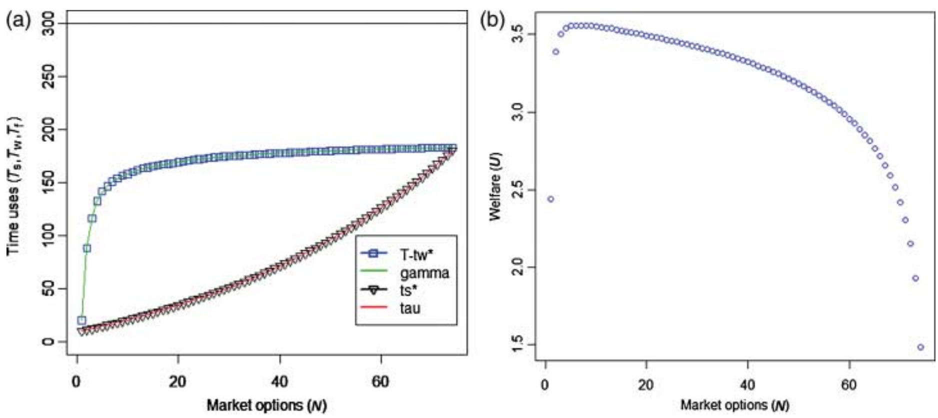

Figure 4. Optimal time allocation as a function of the number of options N (a) and welfare vs. N (b) for a consumer who dislikes shopping (case #3 in Section 3.2.1) (colour online only).

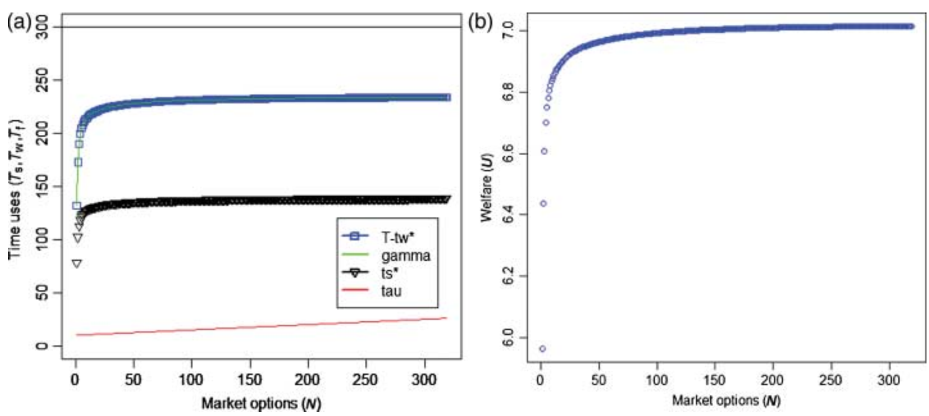

Figure 5. Optimal time allocation as a function of the number of options N (a) and welfare vs. N (b) for an individual who is very efficient in her search behaviour (case #4 in Section 3.2.1) (colour online only).

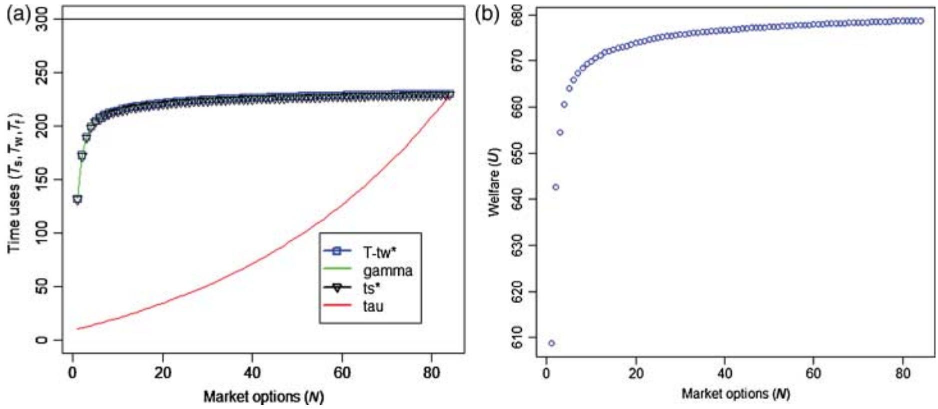

Figure 6. Optimal time allocation as a function of the number of options N (a) and welfare vs. N (b) for an individual who is a shopping lover (case #5 in Section 3.2.1) (colour online only).

T_f is given by the distance between the black curve in triangles and the blue curve in squares, and T_w is the distance between the blue curve in squares and the line $T = 300$.

The curves in Figures 2(b), 3(b), 4(b), 5(b) and 6(b) display the optimal values of welfare versus N computed by the model for each case described above. Two main outputs of the model analysis related with the choice overload problem, i.e. $\bar{N}$ and N^*, can be seen in Figures 2–6. First, notice that in all cases but case #4 there is a value $\bar{N}$ such that $\tau(\bar{N}) = \gamma(\bar{N})$ – i.e. the point at which both curves intersect. It is clear from above that for $N > \bar{N}$ no feasible time distribution does exist, since for such values of N we have $T_s \geq \tau(N) > \gamma(N) \geq T_s + T_f$, which is not possible. The values obtained for $\bar{N}$ in each case are shown in the first column of outputs in Table 1. Second, it is apparent that the welfare function may reach its maximum at a certain value N^* to decrease monotonically from N^* to $\bar{N}$. This can be observed in Figures 2(b), 3(b) and 4(b) corresponding with the cases #1, #2 and #3. It may also be the case that welfare always increases with the number of options, as it can be seen in Figures 5(b) and 6(b) associated with the cases #4 and #5. The values of the output value N^* in each case appear in the last column of Table 1.

3.2.3 *Discussion*

Our analysis clearly shows that a consumer may not check all the available options in the market in her search for a competitive deal. This is evidenced in cases #1, #2 and #3 that may be argued to be typical, since these consumers have a balanced taste for the different uses of time – or a slight dislike for shopping in case #3 – and also inspection of each product option requires a reasonable amount of time. In these three cases the values of $\bar{N}$ for which feasible distributions no longer exist are well below the total number of available options in the market, that is 319 in the case under study. Although the expected price in the market would be reduced by searching beyond $\bar{N}$, the cost in terms of consumer's time T_s is so overwhelming that she runs out of time – since $T_s + T_w > T$ for $N > \bar{N}$ – and in turn she discards looking for more trip options.

In particular, given a common welfare valuation, different profiles of shopping behaviour reduce feasibility by a 44% from $\bar{N} = 223$ to $\bar{N} = 84$ over the total number of tours (319), due to the effect of fatigue in searching. This fact is illustrated by cases #1 and #2 above. Also, a shopping behaviour subjected to fatigue may reduce the number of feasible time distributions in the case that the wage rate is lowered, what can be seen by comparing cases #2 and #3. In case #3, the maximal number of feasible distributions is lowered further to $\bar{N} = 74$. This is clearly linked to paralysis in the choice overload problem. The number of options offered in the market typically surpasses the maximal number of options that a rational consumer is willing to explore, because she feels that the required time – both shopping and working – is just too demanding. The extreme paralysis described by psychologists [12] has its mathematical counterpart here in the disappearance of feasible time distributions. Notice that this paralysis effect is a robust finding in the model analysis in typical cases: its occurrence lies in the fact that a realistic $\tau(N)$ is increasing while $G(N)$ is typically decreasing.

It is expected that consumers of cases #1, #2 and #3 actually will decide to abandon the choice problem when the number of explored options is well below $\bar{N}$. This is due to another key pattern revealed by the analysis that is repeated in each case. It can be seen in Figures 2(b), 3(b) and 4(b) that welfare increases with the number of seen options, but only up to certain number N^*. Beyond N^*, welfare experienced by the consumer monotonically decreases. In our numerical experiment, the number of options that triggers dissatisfaction drops from $N^* = 56$ in case #1 to $N^* = 38$ in case #2. In case #3, this threshold drops to $N^* = 7$, which is a dramatic fall. This finding certainly seems paradoxical, since the consumer is doing better as the number N of seen options increases – she is getting a better deal – but it turns out that she is feeling worse.[3] This may be considered the mathematical version of the so-called 'paradox of choice' as formulated by Schwartz [12].

That consumers will not check all available options, as discussed above, may not be considered a particular finding of our case study but a rather typical situation under standard model specifications about $\tau(N)$ and $G(N)$ and about the consumer's preferences. Notice that it is possible that the curves $\tau(N)$ and $\gamma(N)$ do not cross, as in Figure 5(a) corresponding to case #4, so that the consumer eventually will not suffer from choice paralysis. This is the case of a very efficient shopper, who spend about three minutes examining each available option. This amount of time is so small that $\tau(N)$ does not grow enough to exhaust her total time after having looked at the 319 available options. Also, although the benefit of looking one more option becomes flat for a relatively small number of options (Figure 5(a)) the inspection time per unit is so small that the entailed cost of time does not surpass the benefit of examining more options, even when the number of seen options is as large as 319. As it can be seen from Figure 5(b), welfare is always non-decreasing for this type of consumer so that she does not suffer from choice overload. Even when not all product options are investigated because of the paralysis effect, it may still be possible that welfare never decreases. This is the situation of the consumer defined in case #5, which has a standard searching behaviour – subject to fatigue as in cases #2 and #3 – but an excessive taste for shopping time (Table 1). In turn she spends practically all of her time shopping as shown in Figure 6(a) – although it may not be clearly perceived, her optimal free time is never more than a couple of hours. This consumer enjoys shopping so much that her welfare always increases until she runs out of time, as it can be seen in Figure 6(b). This shopping lover behaviour is not affected by choice overload until entering paralysis. Notice that cases #4 and #5 should be considered atypical since either the search efficiency in case #4 and the love for shopping in case #5 may be considered non-realistic or pathological.[4] In standard settings like those of cases #1, #2 or #3 it is unclear how negative effects due to choice overload could not appear.

4. Conclusions

We provide a flexible model of search-and-buy behaviour based on a rational allocation of time. Three different uses of time are considered – shopping time, free time and working time – to address the pervasive problem of a consumer that faces a huge number of options for a product and can get better deals by investing more time searching in the market. The analysis produces an optimal time allocation in terms of the number of the considered options.

The numerical analysis of the model in a simple case study based on market prices of organized trips around Europe reproduces key features of a consumer's psychology when facing a shopping decision in a market with a vast number of options. The analysis supplies a mathematical formalism for two specific issues raised by psychological research on choice overload, namely the paralysis effect – 'the consumer decides not to decide' and the paradox of choice – 'more options imply less satisfaction'. The model analysis also provides estimates for the number of options that trigger both phenomena.

The model proposes a framework of decision-making in terms of the rational use of time that may give account of the choice overload hypothesis: increasing the number of options eventually has negative effects on the decision maker. The analysis shows that choice overload effects are expected to appear under natural conditions on search time and search benefit and on consumer's time use preferences. So, in the usual case that search and inspection time of a next option increases with the number of seen options whereas the benefit from checking one more option decreases until becoming flat, a welfare maximizer that has balanced preferences over her uses of time eventually will be overloaded by choice beyond a certain number of options. While these findings cannot be claimed to hold in general, the model specifications that can be conceived to escape from choice overload seem very specific or even pathological from a psychological point of view.

Acknowledgments

JMR was partially supported by Ministerio de Ciencia e Innovación (Spain) under Grant MTM2009-12672.

Notes

1. Input data were obtained from the first entry listed by a popular internet search engine for the search term 'organized trips to Europe', namely www.affordabletours.com. Travel data on this website were filtered by 'tour destination to Europe', dates 'June 2013' and length '14 days or more'. A total number of 319 results were obtained (September 2012).
2. The final version of the code was programmed in R, which allows for an easy integration of resampling methods (G), random number generation (τ) and numerical optimization (BFGS is a built-in method). The final outcome was generated on an Intel Core i7, 2.80 GHz PC, under Ubuntu 10.10. Both the code and the original data on prices are available from the corresponding author upon request.
3. Best deals in the three cases #1, #2 and #3 are as follows. Case #1: $N^* = 56$ and $G(56) = 1730.99$\$ after investing $T_s = 65.31$ h searching, spending $T_w = 75$ h working and enjoying herself the remaining time. Case #2: $N^* = 38$ and $G(38) = 1774.12$\$ for $T_s = 66.96$ h and $T_w = 75$ h. Case #3: $N^* = 7$ and $G(7) = 2089.79$\$ for $T_s = 16.87$ h and $T_w = 149.15$ h.
4. Best deals in the cases #4 and #5 are as follows. Case #4: $N^* = 319$ and $G(319) = 1629.00$\$ after investing $T_s = 26.05$ h searching, spending $T_w = 66.45$ h working and enjoying herself the remaining time. Case #5: $N^* = 84$ and $G(84) = 1693.06$\$ for $T_s = 229.20$ h and $T_w = 69.65$ h.

References

[1] A. Caplin, M. Dean, and D. Martin, *Search and satisficing*, Am. Econ. Rev. 101(7) (2012), pp. 2899–2922.
[2] C.F. Chabris, D.I. Laibson, C.L. Morris, J.P. Schuldt, and D. Taubinsky, *The allocation of time in decision-making*, J. Eur. Econ. Assoc. 7(2/3) (2009), pp. 628–637.
[3] A. Chernev, U. Bückenholt, and J. Goodman, *Commentary on Scheibehenne, Greifeneder, and Todd choice overload: Is there anything to it?* J. Consum. Res. 37(3) (2010), pp. 426–428.
[4] S.S. Iyengar and M.R. Lepper, *When choice is demotivating: Can one desire too much of a good thing?* J. Pers. Soc. Psychol. 79 (2000), pp. 995–1006.
[5] K.L. Judd, *Numerical Methods in Economics*, MIT Press, Cambridge, MA, 1998.
[6] E. Kamenica, S. Mullainathan, and R. Thaler, *Helping consumers know themselves*, Am. Econ. Rev. 101(3) (2011), pp. 417–422.
[7] A. Mas-Colell, M.D. Whinston, and J.R. Green, *Microeconomic Theory*, Oxford University Press, New York, 1995.
[8] C. Mogilner, T. Rudnick, and S.S. Iyengar, *The mere categorization effect: How the presence of categories increases choosers' perceptions of assortment variety and outcome satisfaction*, J. Consum. Res. 35(2) (2008), pp. 202–215.
[9] E. Reutskaja and R.M. Hogarth, *Satisfaction in choice as a function of the number of alternatives: When 'goods satiate'*, Psychol. Market. 26 (2009), pp. 197–203.

[10] B. Scheibehenne, R. Greifeneder, and P.M. Todd, *Can there ever be too many options? A meta-analytic review of choice overload*, J. Consum. Res. 37 (2010), pp. 409–425.
[11] B. Schwartz, *Self-determination – the tyranny of freedom*, Am. Psychol. 55 (2000), pp. 79–88.
[12] B. Schwartz, *The Paradox of Choice. Why More is Less*, Harper Perennial, New York, 2004.
[13] H.R. Varian, *Intermediate Microeconomics: A Modern Approach*, W.W. Norton, New York, 2010.