Is Context-Based Choice Due to Context-Dependent Preferences?

by

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Abstract

The rationalization of context-based choice is usually based on the assumption that preferences are context-dependent. In this paper we show that context-based choice can be due to the characteristics of the choice procedure applied by the individual and not to the dependence of preferences (stochastic or deterministic) on the context. Our arguments are illustrated focusing on the much studied dominated-alternative effects.

Keywords: context-based choice, context-dependent preferences, dominated-alternative effects, choice probability, stochastic preferences, stochastic scanning.

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1. Introduction

Various studies show that choice can be affected by context. For example, Dhar & Glazer, 1996; Huber, Payne & Puto, 1982; Mellers & Cooke, 1994; Pettibone & Wedell, 2000; Simonson & Tversky, 1992; Wedell & Pettibone, 1996, among others, found that adding a dominated alternative to the opportunity set, strictly increases the choice probability of some other alternative. In particular, it has been claimed by Tversky, Sattath & Slovic, 1988; Slovic, Griffin & Tversky, 1990; Simonson & Tversky, 1992; Tversky & Simonson, 1993; that preferences are local, adaptive, learned, mutable and manipulated, so context can affect preferences and therefore context-based choice is indeed caused by context-based preferences. [1] [2]

The objective of this paper is to show that context-based choice can be due not to the dependence of preferences (whether such preferences are fixed or stochastic) on the context, but rather to the nature of the choice procedure the individual applies. Our argument is demonstrated using a simple model where choice is made by applying a particular commonly used choice procedure. In our setting, the identity of alternatives and their characteristics are not known in advance, like when choosing a book from among a pile of books or a vacation from a tourist brochure. In such situations the individual typically scans the opportunity set, De Palma, Myers and Papageoriou (1994), Osborne & Rubinstein (1998), Rubinstein (1998). The individual is assumed to apply a particular choice procedure called an *Elimination Scan* where alternatives are scanned in the following manner: first, two alternatives are compared and the preferred one is compared with a new third alternative; the preferred alternative at this second stage is then compared with a new fourth alternative, and so on. The outcome

[1] Specifically, they claim that violation of the *Regularity Principle* is caused by context-based preferences. According to this principle, if $x \in A \subseteq X$, and $P(x{:}A)$ is the probability that x is chosen from A, then $P(x{:}A) \geq P(x{:}X)$, that is, the probability that an alternative is chosen from a set cannot be greater than the probability that it is chosen from any of its subsets.

[2] Alternative explanations for context-based choice and, in particular, choice that violates the independence of irrelevant alternatives property, have been suggested in the context of deterministic preferences. Some of these explanations can be interpreted to imply that context affects standard deterministic preferences. For example, Baharad, & Nizan (2000) suggest that, in general, the opportunity set should be conceived as one of the characteristics of an alternative and, therefore, no wonder that the opportunity set affects preferences defined on alternatives and, in turn, choice. Kalai, Rubinstein, & Spiegler,(2002) suggest that context-based choice can be rationalized by multiple rationales which, again, implies that preferences are context dependent. Other explanations emphasize the role of context in clarifying the nature of the alternatives. For example, Sen (1993) argues that context-based choice is plausible when the opportunity set conveys information about the 'true' identity of the alternatives. Caldwell (1983) and Bandyopadhyay, Dasgupta & Pattanaik (1999) argue that context-based choice is interpreted as arbitrary and irrational, simply, because the alternatives are not identified correctly when the effect of context on the nature of the alternatives is disregarded.

of this scan is the preferred alternative in the last stage (comparison). This outcome is determined by preferences, the number of scanned alternatives and the order in which the alternatives are scanned.

We first clarify that choice can be context-based even if none of the characteristics of the applied scan (and, in particular, preferences) is affected by context. Consider a case where all the alternatives are scanned in a random order and that the individual's preferences are determined by some probability distribution over the set of possible preferences. One interpretation is that the individual has stochastic preferences. An alternative interpretation is that the probability distribution corresponds to the proportion of individuals in a group with fixed preferences, who prefer one alternative to the other. In this setting, adding an alternative to the opportunity set can increase the choice probability of some other alternative. For example, suppose that the initial opportunity set contains only alternatives $\bar{x}$ and x and alternative y is added to this opportunity set. In the extreme case where $\bar{x}$ is always preferred to y, and y is always preferred to x, if y is positioned after $\bar{x}$ in the order of scanned alternatives, the choice probability of $\bar{x}$ cannot decline. However, if y is positioned before $\bar{x}$ in the order of the scanned alternatives, the choice probability of $\bar{x}$ increases, since y is the preferred alternative in the comparison before it is compared with $\bar{x}$. Since every order of scanned alternatives is equally probable, adding y strictly increases the choice probability of $\bar{x}$. In this setting, the driving force behind such context-based choice (the asymmetrically dominated-alternative effect, ADE) is thus the random nature of individual preferences that implies intransitivity and the random nature of the applied choice procedure. We derive the necessary and sufficient condition for the ADE; an increase in the choice probability of the asymmetrically dominating alternative due to the introduction of some other alternative and assess its potential (maximal) magnitude.

We proceed by showing that context-based choice is also possible when some characteristics of the choice procedure, other than preferences, are context-dependent. Consider a situation where preferences are fixed and transitive, the alternatives are scanned in a random order and the number of scanned alternatives is determined by some probability distribution. In this setting, adding a dominated alternative to the opportunity set can increase the choice probability of one of the other dominating alternatives (the symmetrically dominated-alternative effect, SDE). For example, assume that the individual always scans two alternatives. If the opportunity set consists of two alternatives, then the best alternative is always chosen (the second best alternative has a zero choice probability). Adding a third best alternative to the opportunity set, while keeping the number of scanned alternatives fixed, strictly increases the choice probability of the second best alternative to 1/3 (there is a 1/3 probability that the best alternative is not scanned). Hence, in this setting the driving force behind context-based choice, that takes the form of the SDE, is the bounded rationality of the individual (i.e., the possibility that he scans only part of the opportunity set) and the random order of the scanned alternatives. Again, we establish the necessary and sufficient condition for the SDE; an increase in the choice probability of one of the dominating alternatives due to the introduction of an inferior alternative and assess its potential magnitude. Note that different initial two-alternative sets may result in different choice probabilities. This implies that the probability distributions over the number of scanned alternatives (in this case, either one or two alternatives) must be different. In other words, such probability distributions must be context dependent.

Under the above assumptions (stochastic preferences and complete scanning, or, transitive preferences and partial scanning), there is an upper limit (strictly lower than 1) to the ADE and the SDE. We finally show that if, in addition, context-dependent order of scanning is allowed, that is, the order in which the alternatives are scanned depends on the context, then any increase in the choice probability can be rationalized.

The model is presented in section 2. Context-based choice that takes the form of the ADE is discussed in section 3, assuming stochastic preferences and complete scanning. Context-based choice that takes the form of SDE is discussed in section 4, assuming that preferences are deterministic and transitive. The effect of context-dependent order of scanning is dealt with in section 5. The last section 6 contains a brief summary and concluding remarks.

2. The model

Let X be a set of alternatives and $\succ$ a strict complete and asymmetric preference relation on X. Consider an individual who has to choose an alternative, according to

$\succ$, from a finite set of alternatives A, $A \subseteq X$, with cardinality n, $n \geq 2$. Most economic models are based on the assumption that the alternatives the individual faces are known. However, if the alternatives are unknown, as when one chooses a book from among a pile of books or a vacation from a tourist brochure, scanning and some recognition processes are required. In this study the individual is assumed to apply a particular choice procedure. Specifically,

Assumption A1: The individual chooses according to an *Elimination Scan.*

An *Elimination Scan* has two elements:

- An ordered subset of $\succ$. Each element of this subset is called a comparison. The first element of this subset consists of any two alternatives. The second element consists of the preferred alternative in the first comparison and another alternative. The third element consists of the preferred alternative in the second comparison and a new alternative, and so on.
- An outcome, which is the preferred alternative in the last comparison.

In general, the number of scanned alternatives is determined by some probability distribution over the set of relevant possible numbers. In an extreme case the same number of alternatives is always scanned. In particular,

Assumption A2: All the alternatives are scanned.

The individual preferences in our first setting are assumed to be stochastic. Specifically,

Assumption A3: The individual's preferences are determined by some particular probability distribution over the set of possible preferences.

This probability distribution represents the stochastic nature of the individual's preferences [3] that result in some realized preference relation $\succ$. Scanning is based on this realized preference relation $\succ$.

An order $O = < x_1, x_2, ..., x_n >$, is an ordered n-tuple of alternatives in X. $O \in \boldsymbol{O}$, where $\boldsymbol{O}$ is the set of possible orders. An order induces an *elimination scan* as follows. The first comparison is between x_1 and x_2, the second between x_3 and the preferred alternative in the first comparison, and so on. The order that induces the scan applied by an individual is assumed to be determined by a particular probability distribution over the set of possible orders. Specifically,

Assumption A4: Every order is equally probable.

Notice that the characteristics of the choice procedure the individual applies are not context-dependent because they are independent of the identity of the alternatives and therefore of the nature of the opportunity set. These characteristics are also defined independent of the size of the opportunity set the individual faces. And the stochastic preferences of the individual are also fixed and independent of the particular set of alternatives that he faces. In the following section we show how can context-based choice be rationalized under the above assumptions regarding the stochastic preferences and the choice procedure.

3. Feasibility and extent of ADE under stochastic preferences and complete scanning

In this section we focus on a particular context-based phenomenon, viz., the *Asymmetrically Dominated-alternative Effect* (ADE) and demonstrate that it can be obtained under stochastic preferences and complete scanning. *ADE* refers to a situation where adding an alternative dominated by one alternative, but not necessarily by the others, strictly increases the selection probability of the dominant alternative. More precisely, let X' denote the opportunity set that includes alternative y, in addition to all the alternatives in X; that is, $X' = \{X\} \cup \{y\}$. Given **A3**, let us

[3] Alternatively, this probability distribution can be interpreted as representing the proportion of individuals in a group characterized by the possible deterministic preference relations.

denote by $P(x_i \succ x_j)$ the probability that x_i is preferred to x_j. We say that an added alternative y is an *asymmetrically dominated alternative* relative to $\bar{x}$, if:

- $P(\bar{x} \succ y) > 0.5$, that is, alternative y is dominated by $\bar{x}$.
- $P(\bar{x} \succ y) > P(x_i \succ y)$ for every $x_i \in X' \setminus \bar{x}$. That is, the probability that $\bar{x}$ dominates y is greater than the probability that y is dominated by any other alternative. It is easy to verify that if the above assumptions are satisfied, adding an asymmetrically dominated alternative can increase the choice probability of the dominant alternative. For example, let $\bar{x} \in X$, $y \notin X$ and consider the extreme case where $P(\bar{x} \succ y) = 1$ and $P(x \succ y) = 0$ for all $x \in X' \setminus \bar{x}$. In this case, if y is positioned after $\bar{x}$ in the order of the scanned alternatives, the choice probability of $\bar{x}$ cannot decline. However, if y is positioned before $\bar{x}$ in the order of the scanned alternatives, then the choice probability of $\bar{x}$ increases, since y is the preferred alternative in any comparison until its comparison with $\bar{x}$. Since every order of the scanned alternatives is equally probable (random selection applied by the scan), adding y strictly increases the choice probability of $\bar{x}$.

Much of the experimental evidence that confirmed the existence of ADE was obtained in cases where the original opportunity set (the set that does not include the added dominated alternative) contains only two alternatives. Henceforth, for simplicity, we focus on such a set, $X = \{\bar{x}, x\}$ letting $P(\bar{x} \succ y) \equiv \alpha$, $P(x \succ y) \equiv \beta$ and $P(\bar{x} \succ x) \equiv \lambda$.

The following proposition provides the necessary and sufficient condition in our setting for the existence of ADE when n=2.

Proposition 1: Let $X' = \{X\} \cup \{y\} = \{\bar{x}, x\} \cup \{y\}$. Suppose that axioms **A1, A2, A3** and **A4** are satisfied and let $P(\bar{x} \succ y) \equiv \alpha$, $P(x \succ y) \equiv \beta$ and $P(\bar{x} \succ x) \equiv \lambda$. Then

$$P(\bar{x} : X') > P(\bar{x} : X) \text{ iff } 1 \geq \alpha > \frac{\lambda(3-\beta)}{1+2\lambda-\beta}.$$

Proof: By **A3**, the probability that $\bar{x}$ is chosen if y is not added is λ.

If y is added, there are six possible orders of x, $\bar{x}$ and y. In four of these orders, namely $(\bar{x}, x, y)$, $(x, \bar{x}, y)$, $(\bar{x}, y, x)$ and $(y, \bar{x}, x)$, by **A1** and **A3**, the probability that $\bar{x}$

is chosen, is αλ. In the other two orders, namely $(x,y,\bar{x})$ and $(y, x, \bar{x})$, the probability that $\bar{x}$ is chosen is [βλ+(1-β)α]. By **A4**, each of the possible orders is selected in equal probability of 1/6. Hence, adding y increases the choice probability of $\bar{x}$ iff:

(1) $$\frac{4\lambda\alpha + 2[\beta\lambda + (1-\beta)\alpha]}{6} > \lambda$$

or by rearranging (1), iff:

(2) $$\alpha > \frac{\lambda(3-\beta)}{1+2\lambda-\beta}.$$ ■

When y is added to X, the probability that $\bar{x}$ is chosen is equal to (see proof of Proposition 1):

$$\frac{4\lambda\alpha + 2[\beta\lambda + (1-\beta)\alpha]}{6}$$

Let $r(\lambda)$ denote the maximal choice probability given λ. $r(\lambda)$ is obtained when α=1 and β=0. Hence,

$$r(\lambda) = \frac{2\lambda + 1}{3}$$

Consider the two relevant experiments that were conducted by Simonson & Tversky (1992). In the first experiment two groups of individuals were asked to choose between different alternatives: Group I chose between \$6 and an elegant Cross pen, and Group II chose between \$6, a Cross pen and a cheap, unattractive pen. The findings of the experiment are presented below:

Experiment I

	Group I	Group II
\$6	64%	52%
Cross pen	36%	46%
Other pen	-----	2%

Although very few individuals chose the less attractive pen, adding this dominated alternative to the choice set strictly increased the choice probability of a dominant alternative - the Cross pen- from 36% to 46% (an increase of 10% in the choice probability of the dominant alternative, namely a relative increase of 28%).

In the second experiment, two groups of individuals were asked to choose between different alternatives: Group 1 chose between Panasonic microwave I on sale and Emerson microwave, and Group 2 chose between Panasonic microwave I on sale, a different inferior Panasonic microwave II and Emerson microwave. The findings of the experiment are presented below:

Experiment II

Alternatives	Choice probabilities	
	Group 1	Group 2
Emerson	57%	27%
Panasonic I	43%	60%
Panasonic II	-----	13%

Adding the dominated Panasonic II microwave increased the choice probability of the dominant Panasonic I microwave from 43% to 60%, a relative increase of almost 40%.

In the first experiment λ=36% and in the second λ=43% and the maximal choice probability, r(λ), which is obtained when α=1 and β=0, is equal in the first experiment to $r(\lambda)$=57% (versus the actual 46%) and in the second experiment to $r(\lambda)$= 62% (versus the actual 60%). Hence, the actual increase observed in these experiments is well within the range predicted by the model. This means that the evidence in these experiments can be rationalized by our model. In other words, rationalization of the findings does not require reliance on context-dependent preferences and, in particular, on psychological factors such as "local contrasts" (instead of overall value), “loss aversion” and “extremeness aversion”, Simonson & Tversky (1992), Tversky and Simonson (1993).

4. Feasibility and extent of SDE under transitive preferences and partial scanning.

In this section we preserve assumptions **A1,** and **A4**. However, assumption **A2** is replaced with a more general assumption that allows partial scanning and we focus on a special case of **A3**; namely, we make the standard assumption that individuals are characterized by transitive deterministic preferences. Specifically,

Assumption A2': The number of scanned alternatives is determined by a particular probability distribution over the set of possible such numbers.

That is, scanning can be partial. Although this assumption becomes more plausible the larger is the opportunity set, here also, for simplicity, our argument is illustrated utilizing an initial two-alternative opportunity set.

Assumption A3': The individual's preference relation is fixed and transitive.

Under assumptions **A1**, **A2'**, **A3'** and **A4**, it is easy to verify that the addition of a dominated alternative to the opportunity set can strictly increase the choice probability of some other alternative. For example, assume that the individual always scans two alternatives. In this particular case, if the opportunity set consists of two alternatives, then the best alternative is always chosen (the second best alternative has zero choice probability). Adding a dominated (third best) alternative to the opportunity set, while keeping the number of scanned alternatives fixed, strictly increases the choice probability of the second best alternative to 1/3 (by **A4**, there is a probability of 1/3 that the best alternative is not scanned).

As in the pervious section, we derive below the necessary and sufficient condition for the SDE (an increase in the choice probability of one of the dominating alternatives due to the introduction of an inferior alternative) and assess its potential (maximal) magnitude, assuming that the dominated alternative is added to a two-element opportunity set.

Proposition 2: Let *X'*={*X*} ∪ {c}= {a,b} ∪ {c}, where $a \succ b \succ c$. Suppose that axioms **A1, A2', A3'** and **A4** are satisfied and let p_i^X ($p_i^{X'}$) be the probability that the individual scans *i* alternatives from *X* (*X'*) as implied by **A2'**. Then,

P(*b*:*X'*) > P(*b*:*X*) iff $\frac{2}{3}[p_1^{X'} + p_2^{X'}] > p_1^X$.

Proof: By **A2'**, p_1^X is the probability that only one alternative is scanned from *X* and the two alternatives are scanned in the complementing probability p_2^X. The following table shows the conditional choice probability of each alternative corresponding to the number of scanned alternatives, given **A1**, **A3** and **A4**:

Number of scanned alternatives	*a*	*b*
One	1/2	1/2
Two	1	----

The choice probability of *b* from *X,* P(*b*:*X*), is therefore equal to $\frac{1}{2}p_1^X$.

When alternative c is added to the opportunity set, $a \succ b \succ c$, by **A2'**, there are certain probabilities, $p_1^{X'}$, $p_2^{X'}$ and $p_3^{X'}$, that one, two, and three alternatives, respectively, are scanned from *X'*. The following table specifies the conditional choice probability of each alternative corresponding to the number of scanned alternatives, given **A1**, **A3'** and **A4**:

Number of scanned alternative	*a*	*b*	*c*
One	1/3	1/3	1/3
Two	2/3	1/3	----
Three	1	-----	----

The choice probability of *b* from *X'*, P(*b*:*X'*), is therefore equal to $\frac{1}{3}p_1^{X'} + \frac{1}{3}p_2^{X'}$.

Hence, P(*b*:*X'*) > P(*b*:*X*) iff $\frac{2}{3}[p_1^{X'} + p_2^{X'}] > p_1^X$.■

Proposition 2 states the necessary and sufficient condition for an increase in the choice probability of alternative *b* when the inferior alternative *c* is added to alternatives *a* and *b*. In this case the context-based phenomenon is referred to as the *Symmetrically Dominated-alternative Effect* (SDE), because the added alternative is dominated by all the existing alternatives. Clearly, the maximal choice probability of alternative *b* when a dominated alternative is added to the opportunity set is 1/3. Such choice probability is obtained when $p_1^{X'} + p_2^{X'} = 1$.

The actual distribution of the number of scanned alternatives can be inferred from the actual data. Consider the following example: Suppose that $a \succ b \succ c$, and that the choice probabilities when the opportunity set is *X* (Case I) and *X*' (Case II) are given in the following table:

Example: Choice probabilities under *X* and *X*'

Alternatives	Choice probabilities	
	Case I	Case II
a	80%	65%
b	20%	30%
c	-----	5%

The choice probabilities in Case I can be rationalized by our model, if the individual scans two alternatives in probability 0.6 (in such a case alternative *a* is always chosen) and he scans only one alternative in probability 0.4 (in such a case the conditional choice probability of alternative *a* is 0.5). The choice probabilities in Case II can be rationalized by our model, if there is a probability of 0.1 that the individual scans three alternatives (in such a case alternative *a* is always chosen), there is a probability of 0.75 that the individual scans two alternatives (in such a case the conditional choice probability of alternative *a* is 2/3 and the conditional choice probability of alternative *b* is 1/3) and there is a probability of 0.15 that the individual scans only one alternative (in such a case the conditional choice probability of every alternative is 1/3).

In general, the choice probability may vary from one example to another (choice probabilities of 0.8 and 0.2 in Case I of the above hypothetical example vs.

different choice probabilities, possibly 0.7 and 0.3 in some other case, where two different alternatives are compared). This would clearly imply that the probability distribution of the number of scanned alternatives must be context based; that is, depend on the two particular alternatives that are being compared.

5. Context-dependent order of scanning

In the two preceding sections, it has been shown that under stochastic preferences and complete scanning, or alternatively, under transitive preferences and partial scanning, the choice probability of an alternative can increase due to the introduction of a new dominated alternative. Such choice probability is bounded by $r(\lambda) = \frac{2\lambda + 1}{3}$ in the former case and by 1/3 in the latter case. These results are obtained assuming that the order of scanning is random. If the previous assumptions are preserved, however, the random order assumption is relaxed and the order of the scanned alternatives is allowed to be context-dependent, then every possible increase in the choice probability can be rationalized. For example, under stochastic preferences and complete scanning, assume that the only order in which the alternatives are scanned is x, y, $\bar{x}$, that is, first x is compared to y and the winner is compared to $\bar{x}$. If α=1 and β=0, then regardless of the value of λ, $\bar{x}$ is always chosen. Alternatively, under transitive preferences and partial scanning, assume that the only permissible order of scanning is *b*, *c*, *a*. In such a case*,* if the individual always scans two alternatives, then *b* is always the chosen alternative.

6. Conclusion

Various studies claim that context-based choice, and in particular, a violation of the regularity principle that takes the form of the dominated-alternative effect (ADE or SDE) is caused by context-based preferences. In this paper we demonstrated that, even if context has no effect on (fixed or stochastic) preferences, choice may depend on the context. Our argument has been presented using two simple models where individual choice is based on an elimination scanning procedure. We first showed that context-based choice is possible, even when none of the scanning characteristics (and, in particular, preferences) is affected by context. In a setting where preferences are stochastic and the applied scanning procedure is complete, the driving force behind context-based choice is the random nature of individual preferences that implies intransitivity and the random order of the applied scanning procedure. We then clarified that context-based choice can also be due to the fact that some characteristics of the choice procedure, other than preferences, depend on the context. In a setting where preferences are fixed, deterministic and transitive and the scanning procedure is incomplete, the driving force behind context-based choice is the bounded rationality of the individual (i.e., the possibility that he scans only part of the opportunity set) and the random order of the scanned alternatives. We established, in both of these settings, a necessary and sufficient condition for an increase in the choice probability of an alternative when some other alternative is introduced and assessed the potential (maximal) increase in this probability. The arguments have been illustrated applying examples where the number of alternatives increases from two to three. In our first setting, where preferences are stochastic, the two borrowed examples that we used are based on actual experimental evidence. In the second setting, where preferences are deterministic and transitive, we have constructed stylized hypothetical examples that illustrate our points. In the former setting, the particular experimental findings that we used can be rationalized using the proposed model. We finally demonstrated that, in both settings, context-based scanning (order and extent of scanning) enables rationalization of any conceivable context-based choice.

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