Friday, August 14, 2020

Dear Editors,

On behalf of my fellow coauthors (Tomer Ezra and Ophir Friedler), I am submitting our manuscript ``A General Framework for Endowment Effects in Combinatorial Markets '' to be considered for publication in *Games and Econonmic Behavior*. This submission is part of the EC'20 forward-to-journal program.

An earlier version of this work was presented at the ACM Conference on Economics and Computation (EC'20), and a 1-page abstract appeared in the EC'20 conference proceedings. This submission contains the full set of results and proofs that were alluded to in that 1-page extended abstract. We hereby confirm that this manuscript has not been published elsewhere (aside from the 1-page abstract in the EC proceedings) and is not under consideration by another journal.

Our understanding is that the EC'20 reviews for the paper have been forwarded to the contact editor as part of the forward-to-journal program. The reveiwers made several suggestions and comments that we addressed in our revision of the paper. We include a detailed description of our responses and changes in a separate note attached with this letter.

Thank you for considering this manuscript for publication.

Sincerely, on behalf of the authors,

Michal Feldman

Professor

Blavatnik School of Computer Science

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**Addendum: Response to reviewer comments**

In this section, we include the specific comments from the EC reviews that required our

response (minor comments about grammatical or typographical mistakes are all fixed and

are excluded from this section). We are grateful to the anonymous reviewers for their insightful comments.

1. Why absolute loss and not identity function?

We do not claim that the absolute loss effect is more nor less natural than the identity effect. As discussed in the paper, our framework is rich enough to capture different effects that may fit different scenarios. The new results on the absolute loss effect demonstrate that the limit of the power of the endowment effect, as established by previous work, is not a limit on the power of endowment effects in general but rather an artifact of the specific formulation that was proposed by the authors (i.e., the identity formulation). Indeed, when considering stronger effects, such as the absolute loss effect, better results are possible. In addition, the absolute loss endowment effect emerges naturally from the definition of the partial order and thus, it is also interesting from a mathematical viewpoint. We hope that our work will inspire further research regarding meaningful endowment effects in combinatorial settings as well as experimental work that will shed more light on formulations that capture behavior in specific real-life settings.

1. What is the connection to empirical evidence on behavior?

Unfortunately, empirical evidence on behavior in the context of the endowment effect is restricted mainly to simpler settings than the one studied in our paper. Our hope is that this work will inspire further empirical and experimental studies on the endowment effect in more complex settings, such as the combinatorial setting studied in our paper (and in the previous work by Babaioff, Dobzinski, and Sigal, 2018). We view this as an iterative process where each stage refines and informs the next. In particular, the theory inspires empirical and experimental work, and these studies in turn refine the theory and direct it to more applicable regimes. We believe that empirical and experimental studies will help shed more light on suitable formulations in different settings.

1. Does it make sense to think of equilibrium as something we create by imputing endowments?

We believe that this is an interesting question that goes back to the origins of the endowment effect (by Kahneman, Knetsch, and Thaler), and lies at the heart of this concept. Consider for example the original experiment: the subjects were divided into two groups; individuals in Group A received coffee mugs, whereas individuals from Group B received chocolate bars. The mere endowment of these goods to individuals created an equilibrium in which no individual wanted to exchange their good for the one given to the other group. This idea was also suggested in combinatorial settings by Babaioff, Dobzinski, and Sigal (2018).

1. At a high level, the idea of using the endowment effect to identify “relaxations” of WE does not feel particularly natural. Part of what makes a WE so appealing is its decentralized implications and applications to pricing, i.e., if we set the prices to the Walrasian prices/duals, buyers can arrive in any order and purchase a best-response/max-utility set of goods modulo tie-breaking. On the other hand, the endowment equilibrium implies the existence of a centralized authority that allocates goods to buyers. Once the allocation is done, the buyers have no incentive to switch. This seems impractical and the notion of an endowment-equilibrium unfortunately comes across as “yet another relaxation” of a Walrasian equilibrium.

In many real-life scenarios, some type of equilibrium is observed, even in settings where such an equilibrium is unexpected by theory. As the reviewer notes, previous work has suggested different explanations in the form of different relaxations of equilibrium. Our work can be viewed as another relaxation that is based on observed behavior.

Regarding the comment about centralized vs. decentralized allocation, it is true that the process described in our work is more centralized in nature and may fit better resource allocation scenarios that involve the existence of a central authority. Such scenarios are natural in settings where the resource allocation process is handled by an online platform, whose goal is to allocate resources in a way that is both stable and (approximately) efficient.

1. Given the large number of results in the paper, a conclusion would be helpful.
We now have a conclusion section at the end of the paper.
2. It would be useful to discuss the computational aspects of endowment equilibrium. For example, can these be computed any more efficiently than the usual WE?

Thank you for this comment. We added a paragraph that discusses the computational aspects of the algorithm and that finds an endowment equilibrium for XOS markets (in particular, the algorithm may take exponential time). For the computation of an endowment equilibrium in settings with bundling, our algorithm runs in polynomial time (specific details about its run time are given in Section XX of the paper).
More generally, as the reviewer observed, one can imagine scenarios in which computing a WE is difficult, whereas computing an endowment equilibrium is easy. For example, under extreme endowment effects, almost any allocation would be stable. Our interest is mainly in those endowment effects that we deem “reasonable.”

1. In papers like this, the obvious criticism is why this particular endowment effect and not something else. The authors defend it well at the beginning of Section 1.1. In topics like this, I feel theory should be guided by experimental evidence. If possible, more connections to experiments may be given to the particular endowment effects discussed in the paper.

We strongly agree with this sentiment and hope to see more experimental studies on endowment effects in complex settings. For a more elaborate response, see our response above (first comment).

1. I was puzzled by Theorem 5.1 a bit: "There exists an algorithm". Why can we not say that there exists an endowment equilibrium? Why is the "algorithm" important (no computational complexity result is mentioned)? In the price adjustment procedure of Algorithm 1, each agent's endowed valuation is computed from the allocation in every iteration. So, the provisional allocations in each iteration becomes an endowment of the agents and this is used to update prices. So, the particular algorithm used is crucial in reaching an overall endowment equilibrium (see also Lemma 5.6). The authors may clarify and discuss this point further.

The significance of the algorithm is in providing a natural process by which the market can converge to an endowment equilibrium. This also resolves the open problem from Babaioff, Dobzinski, and Sigal (2018). They proved the existence of endowment equilibrium for submodular valuations but raised the question of whether there exists a natural process that converges to an endowment equilibrium. Our algorithm provides such a process. However, as the reviewer points out, it is not a polynomial process (see also our response to Comment 6). We added a short discussion that explains the significance of the algorithm and discusses its computational aspects.