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CAN WE MEASURE PEOPLE´S TIME DISCOUNTING BEHAVIOUR?

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Abstract: This paper addresses the measurement framework underlying experimental works on time discounting and the methodological reasons of the high variability of its empirical results. In particular, the paper discusses the argument that the variability of the results is due to the context-dependency of the processes that motivate people to display discounting behavior.

Keywords: Time discounting, measurement theory, measurement of psychological traits.

1. INTRODUCTION

Individuals engage in discounting behaviour when their decisions are affected by the time dimension of the choice, i.e. the points in time at which the consequences of their choices are expected to occur. Typically, an individual is said to discount for time when she devaluates delayed outcomes in comparison to immediate ones. The evaluation of people's discounting behaviour is of crucial importance in the economics of climate change. In this context, however, the notion of time discounting is used for a variety of different purposes. The cost-benefit analysis of climate policies, for instance, requires introducing a discount rate for comparing costs and benefits that occur at different times in the future. The discount rate of cost-benefit analysis is generally interpreted as an indicator of people's preferences for present versus future consumption. Time discounting, moreover, can be used for predicting people's attitudes towards sustainability and preservation, because people's willingness to engage in climate preservation is supposed to depend on how much they care about the future consequences of their decisions.

Historically, two main elements contributed to the modelling of time discounting: requirements of tractability and the aim to describe people's discounting behaviour. On the one hand, the formal representation of time discounting is such that it can be fitted in pre-existing theories. On the other hand, the theories have been interpreted as providing an approximate description of people's discounting behaviour.

The first systematic theory of time discounting originated with Samuelson [1] and Koopmans [2], who introduced an exponential discounting function with a constant discount rate. The exponential discounting has been derived from relatively few assumptions about the agent's preference ordering. As a consequence, the theory is supposed to hold independently from empirical observations. Despite both the authors being doubtful about the normative and descriptive validity of the model, the exponential discounting has been immediately accepted and today it is the most commonly employed theory of time discounting. The main strengths of this theory are its simplicity and the property of preserving the utility function: the exponential discounting ensures that the agent has a consistent utility function even when engaging in time discounting, allowing an easy integration of the discount rates into economic modelling. Exponential discounting, moreover, has been defended as providing a sufficiently good approximation of people's discounting behaviour.

More recently, time discounting has been the object of an extensive empirical investigation, which involved experimental economics, psychology and neuroscience. Empirical research has gathered evidence that casts doubt on the descriptive validity of exponential discounting: empirical observations have documented several patterns of choice that are inconsistent with the theoretical predictions of exponential discounting. The insights drawn from this empirical research have led to a number of alternative theories of time discounting. Many of these modify the shape of the discounting function from exponential to hyperbolic in order to allow for declining discount rates. Hyperbolic discounting, however, did not become the received view either. Although there is overwhelming evidence that the discount rate used by real people is not constant, but rather tends to diminish through time, the observations are very heterogeneous and not always consistent with the predictions of hyperbolic theory.

The experimental works on time discounting are explicitly intended to capture people's discounting behaviour, but no agreement has been reached on which is the correct way of representing it. As reviewed by Loewenstein et al (2003), this experimental research is characterized by high

heterogeneity of the results and little improvement in the methodological approach [3]. Different elicitation procedures lead to observation of qualitatively different results depending on the underline design of the experiments. Nevertheless, this does not completely explain the variability of the observed discount rates, given that many studies employ the same estimation technique and should therefore lead to similar results. Not only different individuals may display distinct discounting behaviour, but also the same individual may display different discounting behaviour in distinct situations. Furthermore, there is some evidence that dissimilar objects tend to be discounted differently. The cumulative evidence is so heterogeneous and variable that so far no formal theory of time discounting has accounted for all the evidence.

This empirical research had the effect of consolidating the idea that time discounting describes people's discounting behaviour. It became common to justify the choice of particular kinds of time discounting on the basis of empirical evidence. Consider, for instance, the well-known discussion about the discount rate to use for the evaluation of climate policies that arose after the publication of the Stern Review on the Economics of Climate Change [4]. The authors of the Stern Review defended their favoured discount rate on the basis of presumably widespread ethical views regarding inter- and intragenerational justice. Nordhaus and other economists, instead, justified their arguments for market-based discount rates by claiming that they approximate people's revealed time preferences [5]. Despite the differences, both arguments seem to operate under the assumption that the discount rate should capture relevant aspect of people's behaviour.

As the idea that time discounting actually represents people's preferences is becoming more and more common, it is important to ask what exactly can be concluded from these experiments and what the reasons of the variability of the observations are. This paper investigates two main problems of the experimental works on time discounting. Section 2 discusses the argument that the measurement theoretic framework underling existing theories of time discounting limits the kind of behaviour that they can accurately describe. Section 3 discusses the argument that the variability of the empirical results is due to the context-dependency of the cognitive processes underlying people's discounting behavior. Section 4 suggests interpreting the measurement of time discounting in the framework of an alternative approach to measurement, and argues that this approach could resolve part of the problems discussed here.

2. THE MEASUREMENT THEORETIC FRAMEWORK OF TIME DISCOUNTING

Every measurement is based on a representation theorem that links the empirical object of measurement to the resulting numbers. Although this representation theorem can be more or less formal, it is in virtue of this theorem that the numbers can be interpreted as numerical representations of length, temperature, pressure and so on. The meaningfulness of a measurement crucially depends on its measurement theorem, because it is this link that defines what the numbers can reasonably be thought to represent. Providing such theorems, however, can be less straightforward than it might appear at first glance. Conventions and tractability requirements play a dominant role in the definition of the formal representation of the targeted object, so that, in some cases, the requirement of integrating the measure with existing theory overweighs the consideration of how adequately it represents the target object of measurement.

The measurement of human functions is particularly challenging from this point of view, because it is complicated to unambiguously define the targeted object in a way that can be tracked empirically and, at the same time, contains the main features taken to characterize the human function under investigation. The measurement-theoretic foundations of time discounting have recently been investigated by Heimann (2008), who provides a general measurement-theoretic framework underling several existing theories of time discounting [6]. The rest of this section summarizes some of the conclusions of Heilmann's investigation and discusses the implications of the representation theorem that characterizes this framework.

According to Heilmann (2008), many theories of time discounting can be interpreted as measures of time differences in the framework of Krantz and Tversky (1971) and Suppes (2002)'s representational theory of measurement [7] [8]. In this framework, the theories of time discounting provide a numerical representation of a quantitative evaluation of time differences. Individuals are thought to evaluate time differences in a qualitative way, and this evaluation is represented numerically by means of a discounting function. The representation theorem is what establishes a formal relation between the qualitative evaluation of time difference and its functional representation.

In order to make explicit this representation theorem, it is useful to begin by outlining the definition of the targeted object of measurement, that is, the individual evaluation of the difference in time between alternative consequences of a choice. According to this framework, individuals evaluate the time difference between any pair or consequences of their alternative choice-options. In order to express this idea more formally, let P be the present time; C the set of consequence; C x C

the set of pairs of consequences of alternative choice-options. An example of qualitative evaluation is to claim that the absolute difference in time between P and C_1 is larger than the absolute difference in time between P and C_2; which is equivalent to claim that the time difference between C_1 and C_2 is positive. The strategy of this representation theorem is to identify a number of formal requirements that this evaluation is supposed to satisfy, and then prove that the evaluation, as defined by these requirements, can be represented by a discount function. The individual evaluation of time difference has to form a weak order, that is, it has to be possible to order any pair of elements in C x C according to their time difference. This order has to satisfy a number of axioms, such as symmetry and weak monotonicity. There is, moreover, an additional assumption: the evaluation of time difference has to be monotonically related to time as given by a clock. For a full derivation of these axioms and a discussion of their empirical interpretation see Heilmann (2008).

If the individual evaluation of time difference satisfies these axioms, then it can be represented numerically by a discounting function that assigns a discount factor to each future point in time. This function establishes a stable relation between the time at which the outcomes occur and the devaluation of their values. The discount factors assume a value in the interval (0, 1], creating a weighing system that enable to calculate the discounted value of outcomes occurring at any time point. The present time is associated with the full weight (1) and the future time points are associated with weights that decrease as the delay increases – so that time points that are further in the future get smaller weights.

Existing theories differ in the way they interpret time difference and in the richness of the descriptions of the consequences. For instance, as illustrated by Heilmann, the time difference between two consequences C_1 and C_2 can be interpreted as a difference between the degrees of impatience associated with C_1 and C_2, or as a difference of their relative degree of fundamental uncertainty. Despite these differences, many existing theories of time discounting can be thought to be characterized by the representation theorem outlined in this framework, including both exponential and hyperbolic discounting. This might appear a bit surprising, especially because hyperbolic discounting functions have been developed on the basis of empirical works, while exponential discounting was derived from theoretic assumptions. If these theories share the same representation theorem, it means that the empirical works did not produce any modification of the underling measurement framework.

Consider, for instance, the assumption that the evaluation of time difference has to be correlated with clock-time. Although this assumption might be reasonable in a theoretical or normative setting, one should be cautious in including such an assumption in a measurement project. The falsity of this assumption, in fact, could affect the predictive validity of the theory and the empirical adequacy of the measurement. It seems reasonable to think that, in the real works, the individual evaluation of time difference is influenced by a number of factors that are not necessarily related to clock-time. For instance it is common to experience that 10 minutes of delay "feel like ages" when one is waiting for an important result, whereas the same 10 minutes could pass unnoticed when one is waiting is a restaurant in good company. This suggests that the same clock-time difference can be evaluated in very different ways, and that the individual evaluation can fluctuate with respect to time as given by a clock. As noted by Heilmann, this might be one of the reasons of the little predictive power of existing theories of time discounting. For a discussion of the empirical adequacy of other aspects of existing discounting theories see also Loewenstain et al (2003).

Although the observations of people´s discounting behaviour disconfirm several aspects of exponential discounting, and have led to the modification of the discount function, the underlying measurement framework remained unchanged. As a result, it might be reasonable to claim that one of the problems with the modelling of time discounting is that the representation theorem – and especially characterization of the targeted object, depends prevalently on tractability requirements that are empirically suspicious.

3. CONTEXT-DEPENDANCE

Another methodological issue raised by the empirical works on time discounting regards the importance of the context in determining people discounting behaviour. All the theories that can be thought to derive from Heilmann's general framework implicitly assume that discounting behaviour is invariant across contexts. Although Heilmann's framework can in principle account for some context-dependency in the individual evaluation of time differences (by requiring a more comprehensive definition of the consequences of choice), in practice all discounting functions are supposed to depend only on the time at which the future consequences are expected to occur, so that the same discounting function is assumed to be invariant across any other contextual factor. In particular, the discounting functions are supposed to be invariant across different individuals; different objects of discounting; and different kinds of decisions. The empirical evidence, in contrast,

shows that people's discounting behaviour can vary in response to modifications of the context of choice. As reviewed by Loewenstain et al (2003), there is evidence that discounting behaviour varies according to the age, education and culture of the subject, as well as according to the kind of object of discounting and the perceived importance of the consequences of the decision. As a consequence, doubts are casted on the assumption that a unique trait of time discounting is operating in all intertemporal choices. Disputing the assumption that time discounting is the manifestation of a uniform and consistent human trait helps making sense of why so far it has been so difficult to provide a discount function that accounts for all the evidence.

In response to the variability of the experimental results, one might claim that the measurement of time discounting is not well justified, because the results are highly variable and context dependent. The measurement of a human function is generally required to remain relatively constant over the life cycle and across a wide range of situations. Another typical requirement is that different measures of the same trait should be correlated to one another [9]. Since it appears that the measurement of discounting behaviour does not satisfy these requirements, it might be reasonable to claim that discounting behaviour is intractable. In his discussion of experimental evidence of social preferences, Woodward (2008) distinguishes between the use of experimental findings for testing a theory and for measuring people's preferences. He claims that the measurement project requires a "non-trivial degree of stability or robustness" in order to motivate the generalization of the information elicited through the experiments [10]. In contrast, the use of experimental evidence for testing a hypothesis might be reasonable even in the absence of robustness. On this account, although the experimental findings could provide good reasons to reject some aspects of discounting theories, it might not be justified to use these findings for constructing alternative representations of time discounting.

One problem with this way of reasoning is that the definition of the threshold of robustness that the data must have in order to motivate the measurement project is not an easy task. How much of the variability should be skimmed away in the elaboration of the data and how much should instead be regarded as a genuine obstacle of the measurement project is a debatable methodological question. For the present purposes it is sufficient to note that this threshold should be decided according to the specific purposes the measure is intended to cover and that the solution is likely to vary from case to case. For a broader discussion of context-specificity in the construction of measures see Cartwright and Chang (2008) [12].

Another possible reaction to the variability of the empirical findings is to advocate a modification of the underling methodological approach of the measurement. One way of doing this is by criticizing the purely empirical approach taken in many experimental works. The experiments on time discounting focus on the observable effects of time discounting and pay little attention to the cognitive processes that motivates people to display discounting behaviour. Koopmans (1947)'s eminent article about the measurement of economic variables argues that a theory of what motivates individual choice is "an indispensable element in the understanding in a quantitative way the formation of economic variables" [13]. This opinion seems to be shared by contemporary researchers on time discounting. In their introduction to *Time and decision* (2003) Lowenstain et al claim that "the road to understanding intertemporal choice is not through developing better discount functions but through understanding the variety of psychological processes that enter into future decision making". In other words, it is claimed that a meaningful measurement of time discounting requires understanding of the processes that motivates people to display discounting behaviour. For instance, if we could explain why people's discounting behaviour varies according to certain elements of the context we might be able to study the conditions under which the results are robustly informative.

The problem with this line of thought is that it is not always clear what it means to explain people discounting behaviour. In a recent article, philosopher Robert Cummins claims that the understanding of human behaviour requires knowing "how the mind works, not just what it does", meaning that the study of human behaviour requires explaining the conscious and unconscious cognitive processes behind individual choice, rather than merely eliciting the effects of this processes [14]. However, he claims, psychology fall short of explanations of how the mind works. On his account, the reasons for this deficiency are to be found in the "deep-routed uncertainty about what it would take to really explain a psychological effect". Since there is no agreement on what it means to explain a human function, psychological explanations are sometimes interpreted as shaky or incomplete.

A second problem with this way of reasoning is that, as recognized by Cummins, the understanding of a human function does not imply that we can predict or control it. In other words, understanding the processes that motivates people to display discounting behaviour is not sufficient for developing an empirically adequate representation of time discounting. In sum, time discounting cannot be measured without explanation, but being

able to explain it is not sufficient for justifying the measurement project.

3. PURPOSE SPECIFIC METHODOLOGY

This section provides an interpretation of time discounting in the framework of the theory of measurement outlined by Chartwright and Chang (2008) and Cartwright and Bradburn (2011) [15].

According to Cartwright and Chang, the representation theorem of a measurement is constituted by the relation between three elements: the characterization of the targeted object; the formal representation; and the empirical procedure of elicitation. A representation theorem shows that the features taken to characterize the object can be observed by means of the employed procedure and described numerically by the chosen formal representation. This approach makes clear that there is a relation of interdependence between these three elements of a measurement. As a consequence, the definition of the features taken to be true of the targeted object is influenced not only by the need of providing a formal representation, but also by the empirical questions that regard the elicitation procedure.

In the case of time discounting, this approach implies that the considerations about the robustness of the empirical results have a bearing on the definition of the targeted notion of time discounting. Since the experimental findings suggest that discounting behaviour is a multifaceted phenomenon with a number of qualitatively different manifestations, the definition of time discounting might be different according to the specific factors that are thought to influence the decision processes in specific contexts. According to this framework, therefore, the measurement of people's discounting behaviour requires developing many context-specific measures, which might improve the quality of the measurement – both in terms of the robustness of the empirical results and in terms of the meaningfulness of the representations theorems.

The main problem with this approach is that the scope of applicability of these measures would be limited to the contexts for which they have been developed. As recognized by Cartwright and Chang, this approach leads to a "proliferation of measures which become difficult to understand and keep track of". Context-specific measures tend to be idiosyncratic and difficult to compare, however, the employment of inadequate measures risks being not only useless, but also potentially damaging. On Cartwright and Chang's account, the trade-off between the quality of the measurement and its extent of applicability is to be resolved according to the purpose of the measurement.

4. CONCLUSIONS

This paper has argued that the methodology of the experimental measurement of people's discounting behaviour presents two main problems. First, the formal representation theorem of existing theories of time discounting limits the kind of phenomena that can be meaningfully represented by means of these theories. Second, the context-specificity of the cognitive processes that motivate people choices risks undermining the degree of robustness that is required for justifying the measurement project. Both problems call for a further investigation of the methodology of experimental works on people's preferences.

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