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BEHAVIORAL DECISIONS AND WELFARE

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Behavioral Decisions and Welfare*

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Abstract

What are the normative implications of behavioral economics? We study a model where the decisions a person makes, consciously or unconsciously, affect her psychological state (reference point, beliefs, expectations, self-image) which, in turn, impacts on her ranking over available decisions in the first place. We distinguish between standard decisions where the decision-maker internalizes the feedback from her actions to her psychological state, and behavioral decisions where the psychological state is taken as given (although a decision outcome requires that action and psychological state are mutually consistent). In a behavioral decision, the individual imposes an externality on herself. We provide an axiomatic characterization of behavioral decisions. We show that the testable implications of behavioral and standard decisions are different and the outcomes of the two decision problems are, typically, distinguishable. We discuss the consequences for public policy of our formal analysis and offer normative grounds for subsidized psychological therapies.

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Keywords: Behavioral Decisions, Welfare, Revealed Preferences, Normative Preferences

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1 Introduction

Standard normative economics employs the revealed preference approach to extract welfare measures from choice data alone. The *preferences revealed* from the individual's choices are assumed to be identical to the *normative preferences* representing the individual's true interest. Individuals are assumed to choose what is best for them. There is, however, considerable empirical evidence that in an array of different situations, individuals do not appear to do what is best for themselves, establishing a wedge between normative and revealed preferences[1].

Allowing for the possibility that choice may not reveal an individual's best interest, what is the connection between choice and welfare? One approach, advocated in an influential contribution by Bernheim and Rangel (2009), is to construct a welfare criterion that never overrules choice: x is (strictly) unambiguously chosen over y if y is never chosen when x is available. A different approach rejects choice altogether as a foundation for normative analysis and proposes alternative measures of individual welfare based on individual's happiness (Kahneman et. al., 1997), opportunities (Sugden, 2004) or capabilities (Sen, 1985). However, a consensus regarding the appropriate criteria for behavioral welfare analysis has yet to be reached.

This paper proposes a theoretical framework that contributes to this ongoing discussion. Our framework is general enough to encompass a variety of seemingly disconnected *positive* behavioral models, yields non-trivial *testable* implications and provides a *normative* framework to (a) examine the connection between choice and welfare and (b) assess the scope and relevance of a variety of policy interventions.

We study a model where the decisions a person makes, consciously or unconsciously, affect her psychological state[2] (e.g. a reference point) which, in turn, impacts on her ranking over available decisions in the first place. These psychological states could be interpreted as any pay-off relevant preference parameter that can eventually be affected by the choice of the individual, for example, moods, beliefs, self-image, aspirations, attitudes, emotions or values.

In our model, the individual may internalize the effect of her choices on her psychological

[1] Loewenstein and Ubel (2008) point out that in the "heat of the moment," people often take actions that they would not have intended to take and they soon come to regret (Loewenstein, 1996). Koszegi and Rabin (2008) and Beshears et al (2008) review empirical evidence of systematic mistakes people make. Bernheim and Rangel (2007) record situations in which it is clear that people act against themselves: an anorexic refusal to eat; people save less than what they would like; fail to take advantage of low interest loans available through life insurance policies; unsuccessfully attempt to quit smoking; maintain substantial balances on high-interest credit cards; etc.

[2] Throughout the paper, we use "psychological states" or "preference parameters" interchangeably.

states, or she may not. If she does internalize the feedback from actions to psychological states, she chooses an action and, as a consequence, a psychological state, that maximizes her true best interest: this is labelled as a Standard Decision Problem (SDP). If she does not internalize the feedback from actions to psychological states, she chooses an action taking as given her psychological state at the moment she decides, although psychological states and actions are required to be mutually consistent: this is labelled as a Behavioral Decision Problem (BDP).

Consider a decision-maker who chooses a bundle consisting of both material status and health status, who is fully aware of the risk to her health from a single minded pursuit of material status and who has revealed her preferences for health by, for example, paying for costly treatments. In a SDP the decision-maker will internalize any possible trade-off between her material status and health status when choosing her material status while in a BDP, the decision-maker will take her health status as given and strive to achieve the highest possible material status without internalizing how her choice affects her health.

The work reported here contributes to the literature in several ways. First, it unifies seemingly disconnected models in the literature, from more recent positive behavioral economics models to older models of adaptive preferences. The generality of our framework makes it a natural one to study general (positive and normative) properties of behavioral agents. A key feature of our framework is that it is testable based on a "revealed preference" type of analysis. We provide an axiomatic characterization of a BDP and show that observed choices are compatible with a BDP if and only if the choice data satisfy one simple testable condition: the choice correspondence is (weakly) increasing as the choice set shrinks when all alternatives chosen in the larger set are also present in the smaller set. This testable condition, which violates independence of irrelevant alternatives, is weaker than the condition that characterizes a SDP, implying that SDP and BDP have different testable implications. Moreover, we propose a choice experiment where, on the basis of choice data alone, it is possible to infer the divergence between choice and welfare. Third, we provide a new equilibrium existence result in pure actions without complete and/or transitive preferences. A result like that is important on its own, since incomplete and non-transitive preferences are a common token in behavioral economics models. Fourth, we derive the necessary and sufficient conditions under which BDP and SDP outcomes are indistinguishable from each other and show, in smooth settings, that the two decision problems are, generically, distinguishable. Fifth, in our discussion of policy, we argue that the desirability of paternalistic interventions are limited by the information a social planner has about an individual's preferences. Instead, we argue the case for interventions (such as cognitive behavioral therapy) that directly target the non-cognitive abilities (such as emotional intelligence for anger control, capacity to reduce anxiety or to control temptations) needed to internalize the feedback from actions to psychological states.

The remainder of the paper is organized as follows. Section 2 introduces our framework with the aid of some simple examples. Section 3 develops the general framework, studies the testable restrictions of our theory and states the existence result. Section 4 is devoted to an analysis of indistinguishability. Section 5 discusses policy implications. Section 6 reviews relevant literature that could provide philosophical and psychological grounds for our model. The last section concludes and discusses directions for further research. The details of the existence proof is contained in the appendix.

2 Some examples

In this section, we motivate, and illustrate, the distinction between a standard decision problem and behavioral decision problem, via a number of simple examples.

Micro 101 and Behavioral 101:

Consider a consumer choice problem where the decision maker chooses a commodity bundle (x, y) to maximize a standard utility function subject to a budget constraint. Assume preferences are increasing in both x and y. The standard analysis of decision-making in such a setting formulates the maximization problem as

$$max_{\{x,y\}} u(x, y) \ s.t. \ qx + py \leq w, \ \ x, y \geq 0.$$

where p and q are the prices of x and y respectively and w is the wealth of the individual.

Now consider a behavioral decision problem where the decision-maker takes y as given when choosing x. Although when choosing x the individual takes y as given, the amount of y that the individual actually gets to consume for any choice of x must be feasible i.e. be determined by the budget constraint: the outcome of the behavioral decision problem must be consistent with the feedback effect ($y = \pi(x) = \frac{w}{p} - \frac{q}{p}x$) from x to y.

An outcome of a BDP in this example is any non-negative commodity bundle x, y on the budget line i.e. $x + py = w$. Clearly, the individual, except in exceptional cases, cannot be utility maximizing at all these commodity bundles and therefore, most outcomes of a BDP will be welfare dominated.

Although this example is somewhat artificial, it is a special case of general framework where an individual chooses an action a (i.e. choose x) to maximize preferences that also depend on some psychological state p (i.e. y) which is itself affected by the chosen action via a feedback effect $\pi(.)$ (i.e. the budget line). In general, we will make the point that p could be a psychological state, a reference point, an expectation. We will assume that payoffs depend on both the chosen action a and p; moreover, p is consistent with the chosen action via some feedback effect.

Coping Strategies:

Next, consider a student who wants to pass the exam and she will pass it only if she studies, which she does only if she is motivated enough. Her motivation is high if she goes jogging before studying and low if she doesn't. Let p denote a particular motivation level, $P = \{p_1$=feel motivated to study, p_2= don't feel motivated to study$\}$ and $A = \{a_1$=jog and study, a_2=don't jog and study, a_3=jog and don't study, a_4=don't jog and don't study$\}$. The feedback from actions to motivation is given by a map $\pi : A \to P$, where $\pi(a_1) = \pi(a_3) = p_1$ and $\pi(a_2) = \pi(a_4) = p_2$.

In a SDP, the student acknowledges the effect of jogging on his motivation to study and chooses $(a_{1,}p_1)$, that is, to go jogging which motivates her to study and pass the exam. In a BDP, the student disregards the endogeneity of her motivation level, and will end up in a sub-optimal (behavioral) outcome (a_4, p_2) without motivation, not studying and failing the exam.

In this example, the initial motivation of the behavioral student will not affect the outcome of a BDP. If she happens to feel initially motivated to study, she will choose not to go jogging, which in turn triggers p_2 and given p_2, she chooses not to study.

Default option:

Consider a different example where p is the label attached to objects of choice (such as "default option"). Let $A = \{a, a'\}$ and $P = \{p =$"a is the default option", $p' =$"$a'$is the default option"$\}$. Consistency requires that if the chosen action is a the default option is p while if the chosen action is a' the default option is p'. In a BDP, the individual will take the label as given (without taking into account that it is a characteristic pertaining to the object) and may choose a over a' at p and a' over a at p'. In a SDP, the individual will consider the label as a characteristic of the available objects and choose the optimal pair which without loss of generality we may set as (a, p).

Smoking:

Think of a doctor who is a smoker, who is fully aware of the risk of smoking and who has revealed her preferences to quit smoking by paying for costly treatments. This doctor knows that in order to stop smoking she needs to exert self control. Exerting self-control requires the doctor to internalize the feedback from her actions to her psychological state before choosing to smoke i.e. her craving for smoking is affected by her decision to smoke in the first place. A SDP corresponds to scenario where the doctor is able to exert such self-control whereas a BDP corresponds to a scenario where the doctor takes her craving for smoking as given when choosing to smoke.

Dynamic inconsistency:

Interpret p as the time in which a task has to be completed so that $P = \{t = 1, t = 2, t = 3\}$. Let $A = \{a_1, a_2, a_3\}$ where $a_t =$"*complete task at* t*, do nothing at* $t' \neq t$", $t = 1, 2, 3$. Consistency requires that if the chosen action is a_t, $p = t$. In a SDP, the individual will choose both $(a_t, t) \in A \times P$, while in a BDP the individual will take t as given so that, for example, at $t = 1$, a_2 will be chosen while at $t = 2$, a_3 will be chosen, thus being dynamically inconsistent.

The above examples highlight three key features of our framework.

First, at a SDP and a BDP, any decision outcome must be consistent. In a SDP the decision-maker internalizes that her psychological state is determined by her action via the feedback effect. In a BDP the decision-maker takes the psychological state as given although the chosen action and the psychological state have to be mutually consistent via the feedback effect.

Second, the outcomes of a BDP can be welfare dominated. In this sense, in a BDP, the decision-maker imposes an externality on herself. Working out the consequences of this point leads us to results on testability and distinguishability.

Third, a behavioral agent has the potential to make choices that lead to welfare improving outcomes. All she needs is to learn about the map π. In section 5 we address some of the ways in which the agent can learn π.

3 The general framework and some results

3.1 The model

A decision scenario $D = (A, P, \pi)$ consists of a set $A \subset \Re^k$ of actions, a set $P \subset \Re^n$ of psychological states and a map $\pi : A \to P$ modelling the feedback effect from actions to psychological states. It is assumed that $\pi(a)$ is non-empty for each $a \in A$, and $\Re^k$ and $\Re^n$ are finite dimensional Euclidian spaces. A decision state is a pair of action and psychological state (a, p) where $a \in A$ and $p \in P$.

Although a natural starting point is to assume that preferences over A are indexed by p, following Harsanyi (1954), we will need to go beyond the assumptions of the usual ordinal utility theory and make assumptions that guarantee intra-personal comparability of utility. We will assume, not only that the decision-maker is able to rank different elements in A for a given p but also that she is able to assess the subjective satisfaction she derives from an action when the psychological state was p with the subjective satisfaction she derives from another action when the psychological state is p' i.e. to assume that the individual is able to rank elements in $A \times P$. This assumption is critical in order to make meaningful welfare comparisons.

The preferences of the decision-maker are denoted by $\succeq$, a binary relation ranking pairs of decision states in $(A \times P) \times (A \times P)$. The expression $\{(a,p),(a',p')\} \in \succeq$ is written as $(a,p) \succeq (a',p')$ and is to be read as "(a,p) is weakly preferred to (equivalently, weakly welfare dominates) (a',p') by the decision-maker".

A *consistent state* is a decision state (a,p) such that $p = \pi(a)$. Let

$$\Omega = \{(a,p) \in (A \times P) : p = \pi(a) \text{ for all } a \in A\}$$

be the set of consistent decision states.

There are two types of decision problems studied here:

1. A *standard decision problem* (SDP) is one where the decision-maker chooses a pair (a,p) within the set of consistent decision states. The outcomes of a SDP are denoted by S where

$$S = \left\{(a,p) \in \Omega : (a,p) \succeq \left(a',p'\right) \text{ for all } \left(a',p'\right) \in \Omega\right\}.$$

2. A *behavioral decision problem* (BDP) is one where the decision maker takes as given the psychological state p when choosing a. Define a preference relation $\succeq_p$ over A as follows:

$$a \succeq_p a' \Leftrightarrow (a,p) \succeq \left(a',p\right) \text{ for } p \in P.$$

The outcomes of a BDP are denoted by B where

$$B = \left\{(a,p) \in \Omega : a \succeq_p a' \text{ for all } a' \in A,\, p = \pi(a)\right\}.$$

In both a SDP and a BDP, a decision outcome must be a consistent decision state. In a SDP the decision-maker internalizes that her psychological state is determined by her action via the feedback effect. In a BDP the decision-maker takes the psychological state as given although the chosen action and the psychological state have to be mutually consistent.

Some remarks on the interpretation of framework

1. Myopia, anticipation and steady-states of adaptive preferences: We may interpret the outcomes of a SDP and a BDP as corresponding to distinct steady-states associated with an adaptive preference mechanism where the decision-maker's preferences over actions at any t, denoted by $\succeq_{p_{t-1}}$, depends on her past psychological state where p_t is the psychological state for period t. The statement $a \succeq_{p_{t-1}} a'$ means that the decision-maker finds a at least as good as a', given the psychological state p_{t-1}. The decision maker takes as given the psychological state from the preceding period. Note that a BDP corresponds to the steady state of an adjustment dynamics where the decision-maker is myopic (i.e. does not anticipate that the psychological state at $t+1$ is affected by the action chosen at t). Let

$h(p) = \{a \in A : a \succeq_p a',\, a' \in A\}$. Fix a $p_0 \in P$. A sequence of *short-run* outcomes is determined by the relations $a_t \in h(p_{t-1})$ and $p_t = \pi(a_t)$, $t = 1, 2, ...$: at each step, the decision-maker chooses a myopic best-response. *Long-run* outcomes are denoted by a pair a, p with $p = \pi(a)$ and a is defined to be the steady-state solution to the short-run outcome functions i.e. $a = h(\pi(a))$: long-run behavior corresponds to the outcome of a BDP (see also Von Weizsacker (1971), Hammond (1976), Pollak (1978) who make a similar point for the case of adaptive preferences defined over consumption). In contrast, in a SDP, the decision-maker is far sighted (i.e. anticipates that the psychological state at $t+1$ is affected by by the action chosen at t). The outcome of a SDP is one where a is defined to be the steady state solution to $a \in \left\{a \in A : a \succeq_{\pi(a)} a',\, a' \in A\right\}$ and $p = \pi(a)$: in this case, the decision maker anticipates that p adjusts to a according to $\pi(.)$ and taking this into account, chooses a. Note that in this simple framework, in a SDP the decision maker instantaneously adjusts to the steady-state outcome so that p_0, the initial psychological state, has no impact on the steady state solution with farsightedness[3].

2. Reduced form representation: Various interpretations can be given to p, e.g. psychological state, reference point, expectations or, more generally, any dimension of the object of choice that the individual, for some reason, could take as given at the point of making a choice. Are all of these interpretations consistent with our general theoretical framework? Our analysis assumes that an individual's well-being depends on both current action and psychological state. In some cases, the action causes the psychological state (e.g. where an emotion state (e.g. fear, anxiety, stress) or the reference point adjusts quickly to current actions), but in others (e.g. where the state concerns expectations, endowments or beliefs) the states precedes the action, and in this sense, our definition of "consistent decision state" is an equilibrium concept[4]. Consistent with the above interpretation, in the definition of a SDP, internalization (i.e. rationally anticipating the actual effects of one's actions) is equivalent to the decision-maker anticipating equilibrium (e.g. one's own actions is what one expected it to be, or what others expected it to be) and behaving accordingly. It follows that our framework, by allowing for a feedback effect from actions to the psychological state and by making the distinction between a SDP and a BDP, unifies seemingly disconnected models in the literature, from situations where the preference parameter corresponds to the decision maker's current state (Tversky and Kahneman, 1991), beliefs (Geanakoplos, Pearce and Stacchetti, 1989; Akerlof and Dickens, 1982), emotions (Bracha and Brown, 2007), reference points are required to be consistent with chosen actions (Shalev, 2000, Koszegi, 2005;

[3] Non-trivial dynamics would be associated with farsighted behavior if underlying preferences or action sets were time variant.

[4] A similar notion of equilibrium is used in Koszegui and Rabin (2006) and GPS (1989).

Koszegi and Rabin, 2006, 2007) or aspirations (Ray, 2006 and Heifetz and Minelli, 2006) or adaptive preferences over consumption (already referred to in Remark 1 above).

3. Stackelberg vs. Nash in an intra-self game: In a related but distinct vein, we could also interpret the distinction between a SDP and BDP as corresponding to the *Stackelberg and Nash* equilibrium of dual self intra-personal game where one self chooses actions a and the other self chooses the psychological state p and $\pi(a)$ describes the best-response of the latter for each $a \in A$. In a Stackelberg equilibrium, the self choosing actions anticipates that the other self chooses a psychological state according to the function $\pi(.)$. In a Nash equilibrium, both selves take the choices of the other self as given when making its own choices. In this interpretation, it follows that in the welfare analysis reported below, only the preferences of the self that chooses actions is taken into account.

Next, we turn to some examples and show that whether the decision-maker correctly anticipates the feedback effect from actions to the preference parameter or not, has a marked impact on the decision outcomes.

Example 1 ($S \subset B$)

Consider a decision problem where $A = \{a_1, a_2\}$, $P = \{p_1, p_2\}$, $\pi(a_i) = \{p_i\}, i = 1, 2$, and $(a_i, p_i) \succ (a_j, p_i)$, $j \neq i$ and $(a_1, p_1) \succ (a_2, p_2)$. Then, $S = \{(a_1, p_1)\}$ but $B = \{(a_1, p_1), (a_2, p_2)\}$.

Example 2 ($S \neq \varnothing$, $B \neq \varnothing$, $S \cap B = \varnothing$)

Consider a decision problem where $A = \{a_1, a_2\}$, $P = \{p_1, p_2\}$, $\pi(a_i) = \{p_i\}$, $i = 1, 2$, and $(a_2, p_j) \succ (a_1, p_j)$, $j = 1, 2$, and $(a_1, p_1) \succ (a_2, p_2)$. Then, $S = \{(a_1, p_1)\}$ but $B = \{(a_2, p_2)\}$.

Example 3 ($S \neq \varnothing$, $B = \varnothing$)

Consider a decision problem where $A = \{a_1, a_2\}$, $P = \{p_1, p_2\}$, $\pi(a_i) = \{p_i\}$, $i = 1, 2$, and $(a_j, p_i) \succ (a_i, p_i)$, $i \neq j$, and $(a_1, p_1) \succ (a_2, p_2)$. Then, $S = \{(a_1, p_1)\}$ but B is empty.

Example 1 shows the possibility that the outcomes of a BDP may be welfare-ranked and reflects payoffs that arise in situations where the reference point adjusts to actions quickly (e.g. label attached to an alternative (default option) or as discussed in section 5 below, goals and aspirations). In example 2, there is a unique inefficient BDP outcome in dominant actions and could reflect the structure payoffs involved in addiction. Example 3 shows that there may not be solution in pure actions to a BDP and reflects payoffs that arise in a location choice problem (where the location is a psychological state) when "the grass is always greener on the other side".

3.2 Axiomatic characterization of a BDP and testability

Our model is about two distinctive theories of individual behavior: one characterized as a Standard Decision Problem (SDP) and the other as a Behavioral Decision Problem (BDP). We begin by providing an axiomatic characterization of a BDP. Next, we ask whether these theories falsifiable? If so, are the testable implications of each theory different from each other?[5] Below we show that the answer to these questions is yes, they are, in principle, falsifiable and have different testable implications.

|The axiomatic characterization of a BDP is as follows.

Fix $\succeq$, $\pi : A \to P$ and a family $\mathcal{A}$ of non-empty subsets of A. Define two correspondences, $\mathfrak{S}$ and $\mathfrak{B}$, from $\mathcal{A}$ to A as

$$\mathfrak{S}(A') = \left\{a : (a,p) \succeq \left(a', p'\right) \text{ for all } a' \in A',\, p' = \pi(a') \text{ and } p = \pi(a)\right\}$$

and

$$\mathfrak{B}(A') = \{a : (a,p) \succeq \left(a', p\right) \text{ for all } a' \in A' \text{ and } p = \pi(a)\},$$

so, the choices corresponding to a standard and behavioral decision problem, respectively.

Suppose that we observe a correspondence C from $\mathcal{A}$ to A such that $C(A') \subseteq A'$. We say that SDP (respectively, BDP) rationalizes C if there exist P, π and $\succeq$ such that $C(A') = \mathfrak{S}(A')$ (respectively, $C(A') = \mathfrak{B}(A')$).

Consider the following condition:

C1. For all $A', A'' \subseteq A$, if $A'' \subseteq A'$ and $C(A') \cap A''$ is non-empty, then $C(A') \cap A'' \subseteq C(A'')$.

The choice correspondence is (weakly) increasing as the choice set shrinks when all alternatives chosen in the larger set are also present in the smaller set.

Proposition 1. *Choice data are rationalizable as the outcome of a BDP if and only if C1 is satisfied.*

Proof. (i) We show that if choice data is rationalizable as the outcome of a BDP, then, ($C1$) holds. Fix $\succeq$, $\pi : A \to P$. If

$$a \in \mathfrak{B}(A') = \left\{a : (a,p) \succeq \left(a', p\right) \text{ for all } a' \in A',\, p = \pi(a)\right\}$$

and $a \in A'' \subseteq A'$, it follows that

$$a \in \mathfrak{B}(A'') = \left\{a : (a,p) \succeq \left(a', p\right) \text{ for all } a' \in A',\, p = \pi(a)\right\}.$$

Therefore, $C(A') \cap A'' \subseteq C(A'')$ as required.

[5] The analysis presented in this subsection on testability is owed to Andres Carvajal.

(ii) We show that if choice data satisfies $(C1)$, it is rationalizable as the outcome of a BDP. To this end, we specify $\pi : A \rightarrow P$ so that it is one-to-one and onto. Next we specify preferences $\succeq$ as follows. For each $A' \subseteq A$ and $a \in C(A')$, $\succeq$ satisfies the condition that $(a,p) \succeq (a',p)$ for all $a' \in A'$, $p = \pi(a)$ while for each $b \notin C(A')$, $b \in A'$, $\succeq$ satisfies the condition that there exists $c \in A'$ such that $(c,q) \succeq (b,q)$, $q = \pi(b)$. The specification of $\succeq$ otherwise is arbitrary.

Consider $A'' \subseteq A'$ and $a \in C(A'') \cap C(A')$. As $a \in \mathfrak{B}(A')$ implies that $a \in \mathfrak{B}(A'')$, clearly $C(A') \cap A'' \subseteq C(A'')$ for the above specification of $\succeq$, $\pi : A \rightarrow P$. Next, consider $a \in C(A'')$ but $a \notin C(A') \cap A''$. Then, there exists $b \in A'$, $b \notin A''$ such that $(b,p) \succ (a,p)$ but $(a,p) \succeq (a',p)$ for all $a' \in A''$, for the above specification of $\succeq$, $\pi : A \rightarrow P$.

Therefore, there exists $\succeq$, $\pi : A \rightarrow P$ so that $C(A') \cap A'' \subseteq C(A'') = \mathfrak{B}(A'')$ and $\mathfrak{B}(A') = C(A')$ for all $A' \subseteq A$ as required. ■

Manzini and Mariotti (2009) propose a decision-making procedure in which decision-makers categorize alternatives before choosing (CTC). CTC can rationalise pairwise cycles of choice. For example, suppose $A = \{a,b,c\}$ and $C(A) = \{a\}$, $C(\{a,b\}) = \{a\}$, $C(\{b,c\}) = \{b\}$ but $C(\{c,a\}) = \{c\}$. CTC can rationalise this choice data but BDP can't as this data is inconsistent with $(C1)$. However, if $C(\{c,a\}) = \{c,a\}$, the resulting choice data is consistent with BDP[6].

A theory is falsifiable if there exists some outcome that cannot be rationalized as an equilibrium of that theory. For example, standard choice theory is falsifiable if Arrow's (1959) choice axiom holds: when the set of feasible alternatives shrinks, the choice from the smaller set consists precisely of those alternatives that were selected from the larger set and remain feasible, if there are any. What can be said about the testable implications of SDP and BDP?

Consider the following two conditions:

C2. If $A' \subseteq A$ and $C(A) \cap A'$ is non-empty, then $C(A') = C(A) \cap A'$.

When the set of feasible alternatives shrinks, the choice from the smaller set *consists precisely* of those alternatives chosen in the larger set and remain feasible, if there is any.

C3. If $A' \subseteq A$ and $C(A) \cap A'$ is non-empty, then $\{C(A) \cap A'\} \cap C(A')$ is the empty set.

When the set of feasible alternatives shrinks, the choice from the smaller set *does not include* any alternative selected from the larger set and remains feasible, if there is any.

[6] Manzini and Marriotti (2009) show that choice data is rationalizable by CTC if and only if it is rationalizable by the Rational Shortlist Method. They also show that choice data is rationalizable by CTC if and only if it can also be rationalized in the sense of Cherepanov, Feddersen and Sandroni (2008). Therefore, there are choice data that can't be rationalized as the outcome of a BDP but can be rationalised as the outcome of a Rational shortlist method and also rationalized in the sense of Cherepanov, Feddersen and Sandroni (2008).

Note that if $C(A) = \mathfrak{S}(A)$, $(C2)$ holds. Clearly, $(C2)$ holds because if

$$a \in \left\{a : (a,p) \succeq \left(a',p'\right) \text{ for all } a' \in A,\ p' = \pi(a') \text{ and } p = \pi(a)\right\}$$

and $a \in A' \subseteq A$, it follows that

$$a \in \left\{a : (a,p) \succeq \left(a',p'\right) \text{ for all } a' \in A',\ p' = \pi(a'), \text{ and } p = \pi(a)\right\}.$$

Next, by example, we show that if $C(.)$ satisfies $(C1)$ but not $(C2)$ it can be rationalized as the outcome of a BDP but not a SDP. Suppose $A = \{a_1, a_2, a_3\}$. If $C(A) = \{a_1\}$ but $C(\{a_1, a_2\}) = \{a_1, a_2\}$, then C cannot be rationalized as the outcome of a SDP. However, C can be rationalized as the outcome of a BDP by setting $P = \{p_1, p_2, p_3\}$, $\pi(a_1) = p_1$, $\pi(a_2) = p_2$, $\pi(a_3) = p_3$, and $\succeq$ such that:

	p_1	p_2	p_3
a_1	3	1	2
a_2	2	2	1
a_3	1	3	1

In this case, $\mathfrak{B}(A) = \{a_1\}$ and $\mathfrak{B}(\{a_1, a_2\}) = \{a_1, a_2\}$.

Finally, observe that if choice data satisfies $(C3)$ it cannot be rationalized as the outcome of either a SDP and a BDP. Clearly, $(C3)$ contradicts both $(C1)$ and $(C2)$.

We can summarize the above discussion on testability as the following proposition:

Proposition 2. *Both SDP and BDP are testable. Moreover, there are choice data that are rationalizable as the outcome of a BDP but not SDP.*

3.3 Choice and welfare

The recent work on welfare analysis of non-rational choice data relies on ordinal (i.e. choice data) information alone to derive a partial preference ordering based on pairwise coherence (Bernheim and Rangel, 2009; Rubinstein and Salant, 2008; Green and Hojman, 2008 and earlier by Sen, 1971).[7] The issue is whether it is possible, solely on choice data alone, to allow for a divergence between choice and welfare[8]. To this end, we examine the divergence between choice and welfare while relying solely on choice data.

[7]See Dalton and Ghosal (2009) for a detailed comparison between the framework presented here and Bernheim and Rangel's (2009) and Rubinstein and Salant's (2008) framework.

[8]The result reported in the preceeding subsection suggest that when the observed choice data violates $(C1)$ but not $(C2)$, there is at least an argument for further non-choice data (such as psychological data) to potentially qualify the Pareto approach. For example, Green and Hojman (2008) study divergence between choice and welfare which relies on use of cardinal information.

Fix A the set of alternatives. Let $\widetilde{\mathcal{A}}$ denote the set of subsets of A consisting of singletons so that for each $a \in A$, $\{a\} \in \widetilde{\mathcal{A}}$. The choice data we use is generated by the following choice experiment involving two distinct choice scenarios:

Choice Scenario 1: Rank any two choice sets consisting of pairwise comparisons of singleton choice sets i.e. all pairs $\{a\}$ and $\{a'\}$ in $\widetilde{\mathcal{A}}$.

For example, if a is smoking and a' is not-smoking, $\{a'\}$ is a situation in which the option of smoking is not available, and the only available option is "not-smoking" (i.e. go for dinner to a non-smoking restaurant) and $\{a\}$ is a situation in which the option of "not-smoking" is not available and the only available option is to smoke (i.e. go for dinner to a restaurant that only admits smokers).

Choice Scenario 2: Rank the two actions in the choice set where both actions used in the preceding pairwise comparison are already available i.e. actions in $\{a, a'\}$ for each such pair of actions.

For example, choose between smoking and not smoking over dinner in a restaurant where both choices are already available.

The interpretation is as follows. Across all possible pairwise comparisons of actions $a, a' \in A$, in choice scenario 1, the decision maker is being asked to choose between a situation where only action a is available and another one where only action a' is available. In choice scenario 2, the decision-maker has to choose between a and a' when both actions are already available.

For each pair of actions $a, a' \in A$, suppose we observe two non-empty correspondences $\tilde{C}(\{a\}, \{a'\}) \subseteq (a, a')$ and $C(a, a') \subseteq (a, a')$. Consider the following two conditions:

$\widetilde{C}$*1.* $\tilde{C}(\{a\}, \{a'\}) = C(a, a')$, for all $a, a' \in A$;

$\widetilde{C}$*2.* $\tilde{C}(\{a\}, \{a'\}) \neq C(a, a')$, for some $a, a' \in A$;

$\widetilde{C}$*3.* $\tilde{C}(\{a\}, \{a'\}) \cap C(a, a')$ is empty for some $a, a' \in A$.

Condition $\widetilde{C}$*1* states that in any pairwise comparison of $\{a\}, \{a'\} \in \widetilde{\mathcal{A}}$, the decision-maker prefers $\{a\}$ to $\{a'\}$ if and only if the decision-maker chooses a over a' when both actions are already available. Condition $\widetilde{C}$*2* is simply a violation of condition $\widetilde{C}$*1* and $\widetilde{C}$*3*, a specialization of $\widetilde{C}$*2*, states that the decision-maker's choices are reversed when both actions are already available relative to the decision-maker's choice between singleton sets.

The following proposition clarifies the relationship between choice and welfare in our set-up:

Proposition 3. *Suppose there is a pair of actions a, a' such that $\widetilde{C}$1 is violated and $\widetilde{C}$3 is satisfied. Then, the decision-maker's observed choice in the pairwise comparison between a and a' is welfare dominated.*

Proof. In choice scenario 1, the decision-maker, whether behavioral or standard, in any pairwise comparison $\{a\}, \{a'\} \in \widetilde{\mathcal{A}}$, the decision-maker is being forced to choose between the pair $(a, \pi(a))$ and $(a', \pi(a'))$ i.e. between consistent decision-states. Therefore, for any pair of actions $a, a' \in A$, $\tilde{C}(\{a\}, \{a'\}) = \mathfrak{S}(a, a')$. It follows that if the decision-maker solves a SDP, observed choice must satisfy condition $\widetilde{C}\mathit{1}$.

On the other hand, if the decision-maker is behavioral, $\widetilde{C}\mathit{1}$. We show this by example. Let $A = \{a_1, a_2\}$, $P = \{p_1, p_2\}$, $\pi(a_1) = p_1$ and $\pi(a_2) = p_2$ and $\succeq$ is such that

	p_1	p_2
a_1	1	-1
a_2	2	0

Clearly $\mathfrak{S}(A) = \tilde{C}(\{a_1\}, \{a_2\}) = C(a_1, a_2) = a_1$ but $\mathfrak{B}(A) = a_2$.

Finally, suppose $\widetilde{C}\mathit{3}$ is satisfied for some pair of actions $a, a'A$. Without loss of generality, suppose $\tilde{C}(\{a\}, \{a'\}) = \mathfrak{S}(a, a') = a$ but $\tilde{C}(\{a\}, \{a'\}) \cap C(a, a')$ is empty. Then, there exists P and $\pi : A \to P$ such that $(a, \pi(a)) \succ (a', \pi(a'))$ but both $(a', \pi(a)) \succ (a, \pi(a))$ and $(a', \pi(a')) \succeq (a, \pi(a'))$ i.e. $\mathfrak{B}(a, a') = C(a, a') = a'$. Therefore, the decision maker can do strictly better by choosing a different action when both actions are already available.■

Note that the preference relation derived by pairwise coherence as in Bernheim and Rangel (2009) would rank a' over a. However, we conclude that the individual is better off at a than at a' even though the individual always chooses a' when both a and a' are already available.

Continuing with the example of smoking, a behavioral smoker will prefer $\{a'\}$ to $\{a\}$ but will smoke when both a, a' are already available thus revealing a preference for not having the alternative to smoke. A standard smoker (one who chooses to smoke after internalizing the feedback effect) will never choose situation $\{a'\}$ in which "smoking" is a not a possibility.

As Bernheim and Rangel (2005, pp. 40) state "recovering users often manage their tendency to make mistakes by voluntarily removing or degrading future options. They voluntarily admit themselves into "lock-up" rehabilitation facilities, often not to avoid cravings, but precisely because they expect to experience cravings and wish to control their actions".

3.4 Existence

So far we have implicitly assumed that both SDP and BDP are well-defined i.e. lead to well defined outcomes. In what follows, we check for the existence of solutions to a SDP and a BDP in situations where the underlying preferences are not necessarily complete or transitive and underlying action sets are not necessarily convex. Mandler (2005) shows that incomplete preferences and intransitivity is required for "status quo maintenance" (encompassing endowment effects, loss aversion and willingness to pay-willingness to accept diversity) to be outcome rational. Tversky and Kahneman (1979, 1991) argue that reference dependent preferences may not be convex. So we allow preferences to be incomplete, non-convex and acyclic (and not necessarily transitive) and we show existence of a behavioral equilibrium in pure actions extending Ghosal's (2009) result for normal form games to behavioral decision problems[9][10].

Proposition 4. *Suppose for each a, $\pi(a)$ is a compact sublattice of P and the map $\pi : A \to P$ is increasing in A. Under assumptions of single-crossing, quasi-supermodularity and monotone closure*[11]*, a pure action behavioral equilibrium exists.*

Proof. See Appendix. ■

4 Indistinguishability

How relevant is the distinction between a BDP and a SDP? In this section, we derive the necessary and sufficient conditions under which BDP and SDP outcomes are indistinguishable from each other and show, in smooth settings, that the two decision problems are, generically, distinguishable.

A BDP is indistinguishable from a SDP if and only if $B = S$. Note that indistinguishability is, from a normative viewpoint, a compelling property. What matters for welfare purposes is the ranking of consistent decision states, which is the preference relation that a standard decision maker will use to make a decision. When $B = S$, the outcomes (consistent decision states) of a SDP coincide with that of a BDP, and therefore whether or not the decision maker internalizes the feedback effect has no normative implications at all.

If $\pi(a) = \pi(a')$ for all $a, a' \in A$, a BDP is, by construction, indistinguishable from a SDP[12]. So suppose the map $\pi(a) \neq \pi(a')$ for some pair of distinct actions a, a'.

Consider the following conditions:

$\hat{C}1$: For (a, p), $(a', p') \in \Omega$ if $a \succeq_p a'$, then $(a, p) \succeq (a', p')$;

$\hat{C}2$: For (a, p), $(a', p') \in \Omega$ such that $(a, p) \succeq (a', p')$, $a \succeq_p a'$.

Fix the consistent states (a, p), (a', p'). Condition ($\hat{C}1$) states that if the action a weakly dominates the action a' at the psychological state p, then the pair (a, p) also weakly

[9]The seminal proof for existence of equilibria with incomplete preferences in Shafer and Sonnenschein (1975) requires convexity both for showing the existence of an optimal choice and using Kakutani's fix-point theorem.

[10]The decision problem studied in example 3 is inconsistent with the conditions of complementarity required for existence in Proposition 3.

[11]These terms are all defined in the appendix below.

[12]In this case, p is exogeneous to individual choice and therefore, both, standard and behavioral decision makers rank actions in the same way.

dominates the pair (a', p'). Condition $(\hat{C}2)$ states that if the pair (a, p) weakly dominates the pair (a', p'), then the action a weakly dominates the action a' at the psychological state p.

Note that preferences in Example 1 violate $(\hat{C}1)$ but satisfy $(\hat{C}2)$ while the preferences in Example 2 violate both $(\hat{C}1)$and $(\hat{C}2)$. Shalev (2000) shows (in Theorem 1 of his paper) that in the static case his loss averse preferences satisfy both $(\hat{C}1)$ and $(\hat{C}2)$. Geanakoplos, Pearce and Stacchetti (1989) construct examples where, with one active player, both $(\hat{C}1)$ and $(\hat{C}2)$ are violated.

In the following result, we show that $(\hat{C}1)$ and $(\hat{C}2)$ are necessary and sufficient conditions for indistinguishability.

Proposition 5. *Suppose that both B and S are non-empty. Then, (i) $B \subseteq S$ if and only if $(\hat{C}1)$ holds. (ii) $B \subseteq S$ if and only if $(\hat{C}2)$ holds.*

Proof: (i) Suppose $(a, p) \in B$. By definition, for all $a' \in A$, $a \succeq_p a'$ for some $p = \pi(a)$. By $(\hat{C}1)$, for all $a' \in A$, $(a, p) \succeq (a', p')$ for each $p = \pi(a)$ and $p' = \pi(a')$. It follows that $(a, p) \in S$. Next, suppose, by contradiction, $(a, p) \in B \cap S$ but $(\hat{C}1)$ doesn't hold. As $(a, p) \in B$, for all $a' \in A$, $a \succeq_p a'$ for $p = \pi(a)$. As, by assumption, $(\hat{C}1)$ doesn't hold there exists $a' \in A$ such that $a \succeq_p a'$ for $p = \pi(a)$ but $(a, p) \prec (a', p')$ for $p = \pi(a)$ and $p' = \pi(a')$. But, then, $(a, p) \notin S$, a contradiction.

(ii) Suppose $(a, p) \in S$. As $(a, p) \succeq (a', p')$ for all $(a', p') \in \Omega$, by $(\hat{C}2)$, $(a, p) \succeq (a', p)$ for $p = \pi(a)$. It follows that $(a, p) \in B$. Next, suppose, by contradiction, $(a, p) \in S \cap B$ but $(\hat{C}2)$ doesn't hold. As $(a, p) \in S$, $(a, p) \succeq (a', p')$ for all $(a', p') \in \Omega$. As, by assumption, $(\hat{C}2)$ doesn't hold, there exists $a' \in A$ such that $a' \succ_p a$ for $p = \pi(a)$. But, then, $(a, p) \notin B$, a contradiction.■

That $(\hat{C}1)$ rules out welfare dominated outcomes of a BDP or that $(\hat{C}2)$ ensures that the outcomes of a SDP are also a BDP isn't perhaps surprising; that both $(\hat{C}1)$ and $(\hat{C}2)$ are necessary for indistinguishability is of greater interest.

To further understand the conditions under which indistinguishability occurs, it is convenient to look at smooth decision problems where decision outcomes are characterized by first-order conditions. We show that for the case of smooth decision problems, behavioral decisions are generically *distinguishable* from standard decisions.

A decision problem is smooth if (a) both A and P are convex, open sets in $\Re^k$ and $\Re^n$ respectively, (b) preferences over $A \times P$ are represented by a smooth, concave utility function $u : A \times P \to \Re$ and (c) the feedback map $\pi : A \to P$ is also smooth and concave.

A set of decision problems that satisfies the smoothness assumptions is *diverse* if and only if for each $(a, p) \in A \times P$ it contains the decision problem with utility function and feedback effect defined, in a neighborhood of (a, p), by

$$u + \lambda p$$

and

$$\pi - \mu(a' - a)$$

for each a' in a neighborhood of a and for parameters (λ, μ) in a neighborhood of 0.

A property holds generically if and only if it holds for a set of decision problems of full Lebesgue measure within the set of diverse smooth decision problems.

Proposition 6: *For a diverse set of smooth decision problems, a standard decision problem is generically distinguishable from a behavioral decision problem.*

Proof: Let $v(a) = u(a, \pi(a))$. The outcome $(\hat{a}, \hat{p})$ of a SDP satisfies the first-order condition

$$\partial_a v(\hat{a}) = \partial_a u(\hat{a}, \pi(\hat{a})) + \partial_p u(\hat{a}, \pi(\hat{a}))\partial_a \pi(\hat{a}) = 0 \qquad (1)$$

while the outcome (a^*, p^*) of a BDP satisfies the first-order condition

$$\partial_a u(a^*, p^*) = 0, p^* = \pi(a^*). \qquad (2)$$

For $(a^*, p^*) = (\hat{a}, \hat{p})$, it must be the case that

$$\partial_p u(a^*, p^*)\partial_a \pi(a^*) = 0. \qquad (3)$$

It is easily checked that requiring both $(\hat{C}1)$ and $(\hat{C}2)$ to hold is equivalent to requiring that the preceding equation also holds.

Consider a decision problem with $(a^*, p^*) = (\hat{a}, \hat{p})$. Perturbations of the utility function and the feedback effect do not affect (2) and hence (a^*, p^*) but they do affect (3) and via (1) affect $(\hat{a}, \hat{p})$. Therefore, $(a^*, p^*) \neq (\hat{a}, \hat{p})$ generically. ∎

Eq. (3) shows in a simple quick way that BDP and SDP are indistinguishable only in isolated cases (e.g. when $\pi(a^*)$ or $u(a^*, p^*)$ are just constants)[13].

[13] Note that if payoffs over actions have a value function component a la Kahneman and Tversky (where the psychological state is a reference point), the decision problem isn't necessarily smooth or even concave. We note that the first-order approach adopted in Proposition 5 can be extended to non-smooth decision problems as long preferences are concave overall (even though an individual component such as a value function may be non-concave). This would cover cases where $u(a, p) = f(a) + g(a - p)$ where $g(.)$ is a Kahneman-Tversky value function with loss aversion and $u(a, p)$ is concave in a for any fixed p and $v(a) = f(a) + g(a - \pi(a))$ is concave in a. This would be the case when $f(a)$ is concave and $g(.)$ is piece-wise linear with a kink at zero. Essentially, we will need to work with the subgradient of $v(.)$ and $u(.)$ and note that at an action a is an interior optimum of $v(.)$ if and only if it is contained in the subgradient of $v(a)$ and for each fixed p, an action a, p is an interior optimum of $u(a, p)$ if and only if it is contained in the subgardient (with respect to a) of $u(a, p)$ (Hiriart-Urruty and Lemarechal (2001)).

Further, as examples 1-3 discussed above show, the outcomes of a BDP in distinguishable decision problems have properties very similar to those of two person normal form games.

Beshears et. al (2008) provide empirical evidence in support of our theoretical point. They describe situations in which revealed preferences deviate from normative preferences. They identify factors that increase the likelihood of having distinguishable decision problems, and discuss approaches to the identification of normative preferences when decision problems are distinguishable.

5 Behavioral Public Policy

What are the policy implications of behavioral decision making, i.e. assuming that people don't necessarily follow their own best interests?

The goal of any public policy ought to be to maximize people's well-being. The route a social planner chooses to take in order to achieve that goal will depend on the social planner's beliefs, her information on underlying preferences and feedback effects as well as on *the way* the individual chooses i.e. whether the individual is solving a BDP or a SDP.

Fix (A, P, π). Let $v(a) = u(a, \pi(a))$. We assume that the social planner's goal is to maximize $v(a)$ choosing an action $a \in A$.

We distinguish between four different kinds of intervention:

(i) direct paternalism: impose a choice a on the individual;

(ii) indirect paternalism: impose a tax or a subsidy on the individual;

(iii) soft paternalism: choosing the initial p_0 (e.g. reference point) for the individual;

(iv) soft libertarian: use therapies (such as cognitive behavior therapies) that allow the individual to internalize the feedback effect.

5.1 Direct paternalism

In the complete information case, the social planner would simply choose an action[14] $a \in \arg\max_{a\in A} v(a)$. In this case, if the decision problem is distinguishable and the individual is solving a BDP, the social planner could directly impose a choice a on the individual.

Suppose that the social planner has incomplete information about whether the decision maker is solving a BDP or a SDP but has complete information about preferences and the feedback effect. Suppose the social planner attaches a probability μ to the decision-maker solving a BDP. In this case, the social planner believes that the individual solves:

[14] Examples of direct paternalistic policies include banning narcotics, warnings on cigarettes, public health advertising, safety regulations such as the use of helmet or seatbelts, etc.

$$Max_{\{a \in A\}} \mu v(a) + (1-\mu) u(a,p)$$

where with some probability μ she takes the feedback effect from actions to preference parameters into account, and with some probability $(1-\mu)$ she does not. The FOC is:

$$\mu \begin{bmatrix} \partial_a u(\tilde{a}, \pi(\tilde{a})) \\ +\partial_p u(\tilde{a}, \pi(\tilde{a})) \partial_a \pi(\tilde{a}) \end{bmatrix} + (1-\mu) [\partial_a u(\tilde{a}, \tilde{p})] = 0$$

$$\tilde{p} = \pi(\tilde{a}) \qquad (4)$$

Let $(\tilde{a}(\mu), \tilde{p}(\mu))$ denote the solution. Note that $(\tilde{a}(1), \tilde{p}(1)) = (\hat{a}, \hat{p})$ while $(\tilde{a}(0), \tilde{p}(0)) = (a^*, p^*)$.

Suppose the social planner attaches a probability μ' to correct preferences and feedback effect but with probability $(1-\mu')$ the social planner uses a completely wrong set of preferences or feedback effect resulting in attaching a weight $(1-\mu')$ to some function $v' : A \to R$, $v'(\cdot) \neq v(\cdot)$ where $v'(a) = u'(a, \pi'(a))$. Then, the the social planner maximizes:

$$Max_{\{a \in A\}} \mu' v(a) + (1-\mu') v'(a)$$

The FOC is:

$$\mu' \begin{bmatrix} \partial_a u(a', \pi(a')) \\ +\partial_p u(a', \pi(a')) \partial_a \pi(a') \end{bmatrix} + \left(1-\mu'\right) \begin{bmatrix} \partial_a u'(a', \pi'(a')) \\ +\partial_p u'(a', \pi'(a')) \partial_a \pi'(a') \end{bmatrix} = 0 \quad (5)$$

Let $[a'(\mu), p'(\mu)]$ denote the solution. Note that $[a'(1), a'(1)] = [\hat{a}, \hat{p}]$.

It follows that the extent of direct paternalism is limited by the trade-off between μ and μ'. If the decision-maker is solving a SDP with very high probability (high μ) and the social planner has relatively imprecise information about the individual (low μ'), then intervention may cause more harm than good. On the other hand, if μ is low and μ' is high, then intervention could lead to welfare improvements.

5.2 Indirect paternalism

In the transferable utility case, instead of imposing action directly on the individual the social planner could impose a per unit tax (or a subsidy) which would induce the individual to make the right choice. If first-order conditions are valid in characterizing an optimum for both a SDP or a BDP, then the tax $t \in \Re$ would work as follows. The outcome (a^*, p^*) of a BDP with a tax $t \in \Re$ satisfies the first-order condition

$$\partial_a u(a^*, p^*) + t = 0, p^* = \pi(a^*). \qquad (6)$$

so that by setting $t=-\partial_p u(\hat{a},\pi(\hat{a}))\partial_a\pi(\hat{a})$ the social planner would ensure that at a BDP the individual chooses the same action as in a SDP.

Note, however, that the above solution relies on the social planner having information about the underlying preferences and feedback effect but also whether the individual is solving a BDP or a SDP.

Suppose that the social planner has incomplete information about whether the decision maker is solving a BDP or a SDP and attaches a probability μ to the decision-maker solving a SDP. It follows from (5) that by imposing a tax $t(\mu)=-(1-\mu)\left[-\partial_p u(\hat{a},\pi(\hat{a}))\partial_a\pi(\hat{a})\right]$, the social planner ensures that $[\tilde{a}(\mu),\tilde{p}(\mu)]=[\hat{a},\hat{p}]$. Note that the absolute value of t is decreasing in μ and will be a function of the degree of uncertainty the social planner has about whether the individual is solving a SDP or a BDP. However, for any fixed value of $t(\mu)$, the decision-maker never achieves a SDP outcome. If the decision-maker is solving a SDP, there will be distortion; further, by substitution in (6), the actual outcome of a BDP will not coincide with that of a SDP.

Suppose now the social planner attaches a probability μ' to the correct preferences and feedback effect and with probability $(1-\mu')$ the social planner uses a completely wrong set of preferences or feedback effect resulting in attaching a weight $(1-\mu')$ to some function $\tilde{v}: A\rightarrow R$, $\tilde{v}(\cdot)\neq v(\cdot)$. Then, the target for the social planner is $[a'(\mu'),p'(\mu')]$. If the social planner believes that the individual is solving a BDP with probability 1, the social planner will set a tax $t'(\mu)=-(1-\mu)\left[-\partial_p u(a'(\mu'),\pi(a'(\mu'))\partial_a\pi(a'(\mu'))\right]$ which will distort matters further a conclusion reinforced if, in addition, the social planner believes with probability $1-\mu$ the individual is solving a BDP.

As in the case of direct paternalism, the extent, and usefulness, of indirect paternalism is limited by the information available to the social planner.

5.3 Soft paternalism

Note that so far we have only considered the case of "hard" paternalism, in which the social planner chooses an action instead of the individual. Intermediate forms of *soft paternalism* have recently emerged as a compromise between fully libertarian and pure paternalistic views[15]. The goal of *soft paternalistic* policies is to guide individual's behavior in directions that will promote individual's welfare while minimizing coercion.

Thaler and Sustein (2003) recommend a type of soft paternalism labelled *libertarian paternalism*. They argue that, in the cases in which the choice is reference-dependent (e.g. status quo bias or default option bias), the social planner should choose the reference point

[15] See Loewenstein and Haisley (2008) for a review of methodological issues that arise in designing, implementing and evaluating the efficacy of "soft" paternalism.

or default option in order to steer people's choices in desirable directions. In this way, the social planner would achieve her goal of maximizing people's welfare without forcing anybody to do anything they wouldn't do.

To what extent are their conclusions affected when reference points adjust quickly to actions? Note that if there is a unique outcome of a BDP, then the initial policy-determined reference point will not have an impact on the steady state preferences to which the decision-maker with adaptive preferences converges to. On the other hand, if there are multiple BDP, then the initial policy determined reference point might have an impact by selecting which steady-state preferences the decision-maker converges to.

To make this point precise, consider the following example where some internal state of the individual (such as self-image, goals[16], self-confidence) of an individual adjusts to her actions. Consider an individual whose decision-making problem involves the following payoff-relevant variables:

(i) a set of actions $A = \{\underline{a}, \overline{a}\}$, $\underline{a} < \overline{a}$, where $\underline{a}$ represents maintaining the existing status quo and $\overline{a}$ represents changing the existing status quo by undertaking higher effort (going to College, working harder at school, undertaking additional training, embarking on a new project, etc.). and

(ii) a set of psychological states P where $p \in P$ represents the reference point of the individual.

The preferences of the individual are represented by a utility function $u(a,p) = b(a) - c(a,p)$, where $b(a)$ is the benefit the individual obtains from her new social status and $c(a,p)$ is the *perceived* cost of effort, which is decreasing in p but increasing in a. For simplicity, assume that $u(\underline{a}, p)$, the individual's utility from preserving the status quo, is normalized to zero for all values of p and for each p, $u(\overline{a}, p)$ is the perceived net gain (or loss) to the individual in deviating from the status quo. Then, under the assumptions made so far, $u(\overline{a}, p') > u(\overline{a}, p)$, for $p' > p$. For example, if $\overline{a}$ is interpreted as going to College, and $\underline{a}$ as staying at home, this inequality implies that the higher the person's aspirations (self-image, self-confidence), the more she enjoys College. In addition, assume that $u(\overline{a}, p)$ is continuous in p.

For each p, the individual solves the maximization problem

$$\max_{a \in A} u(a,p)$$

This generates an optimal action correspondence $\alpha(p) = \arg\max_{a \in A} u(a,p)$. Under our

[16] Appadurai (2004) and Ray (2006) discuss the way an individual can fail to aspire. Based on their insights, Heifetz and Minelli (2006) study a model of aspiration traps where an individual in period $t = 0$ makes a choice which will affect her attitude for the rest of her life. Here we introduce an example that can be considered as a reduced representation of their work.

assumptions there is a unique solution $\hat{p}$ to the equation $u(\overline{a}, p) = 0$. Given p, the optimal action correspondence of the individual is determined as follows:

(i) whenever $p < \hat{p}$, $\underline{a} = \alpha(p)$;

(ii) whenever $p > \hat{p}$, $\overline{a} = \alpha(p)$;

(iii) whenever $p = \hat{p}$, $\{\underline{a}, \overline{a}\} = \alpha(p)$.

Therefore, an individual with sufficiently low p will prefer to remain in status-quo, whereas an individual with sufficiently high p will see it as convenient to exert effort to change her status-quo.

The feedback effect from actions to p is captured by an increasing function $\pi : \{\underline{a}, \overline{a}\} \rightarrow P$, that assigns a p to each action. For example, the fact that the person goes to College generates a higher p. Let $\underline{p} = \pi(\underline{a})$ and $\overline{p} = \pi(\overline{a})$, $\underline{p} < \overline{p}$, be the lowest and highest values of the psychological variable consistent with the actions available. That is, going to College is consistent with endorsing high aspirations (self-image, self-confidence), and staying at home is consistent with endorsing low aspirations (self-image, self-confidence).

In a SDP, the individual internalizes the effect of her actions on her aspirations and then chooses $a \in \text{argmax}_{a \in A} u(a, \pi(a))$.

In a BDP, the individual takes as given the effect of her actions on her aspirations and then chooses $a \in \text{argmax}_{a \in A} u(a, p)$ given $p \in P$.

Suppose $\underline{p} \leq \hat{p} \leq \bar{p}$. then, there is a unique SDP outcome $(\overline{a}, \overline{p})$, but two BDP outcomes $\{(\underline{a}, \underline{p}), (\overline{a}, \overline{p})\}$[17]. Call $(\underline{a}, \underline{p})$ a type I equilibrium and $(\overline{a}, \overline{p})$ a type II equilibrium. In a type I equilibrium, there is no change in the status quo while in a type II equilibrium there is a change in the status quo: observe that a type II equilibrium welfare dominates a type I equilibrium.

If the social planner knows the preferences and the feedback effect, by fixing $p_0 > \hat{p}$, irrespective of whether the individual is solving a SDP or a BDP, the individual will end up choosing $\bar{a}$: the social planner can always ensure that the individual will always end up at a type II equilibrium.

However, for this to be effective, the planner must know the correct value of $\hat{p}$ which, in turn, requires the planner to know the underlying preferences. If the social planner does not know this, she could end up choosing a value of p_0 that is too low and therefore, ineffective.

Again, as in the cases of direct and indirect paternalism, the extent, and usefulness, of soft paternalism is limited by the information available to the social planner.

[17]The two other cases are: (i) if $\bar{p} < \hat{p}$, there exists a unique standard and behavioural equilibrium: $(a^*, p^*) = (\underline{a}, \underline{p})$; (ii) if $\underline{p} > \hat{p}$, there exists a unique standard and behavioural equilibrium: $(a^*, p^*) = (\overline{a}, \overline{p})$.

5.4 Soft libertarian

Finally, we consider a soft-libertarian approach which directly addresses the point that in a BDP, the individual doesn't internalize the feedback effect.

A soft libertarian policy is any intervention that aims at helping the decision maker to internalize his feedback effect. It stands in between a fully libertarian (i.e. no intervention) and a libertarian paternalistic approach. Instead of being the social planner the "architect of the decision-maker choice" as proposed by the libertarian paternalistic approach, we propose the decision maker herself to become the "architect of her own choice" or, in Elster's (1983) words, her "own character planner". In that sense, the soft libertarian approach is not coercive and moreover, it does not require the social planner to know the underlying preferences, the feedback effect or the decision making procedure. It is sufficient to test whether observed choices satisfy C1, which characterizes a BDP and violates SDP. If that is the case, learning how to internalize the feedback effect will be individual welfare improving.

Note that, in order to internalize a feedback effect, a person must acknowledge the existence of a feedback map, characterize it (e.g. which actions and how they impact on preferences parameters) and finally implement her optimal/standard decision. Doing this may not be easy for some people. It requires capacities and information that may seem unimportant with the lens of standard economic theory but they are crucial in the framework proposed here.

How can an individual learn to internalize his feedback effect? The answer to this question depends very much on the type of decision problem at hand. Simple feedback effects can be learned with personal experience or the experiences of similar others (e.g. role models). For example, as highlighted in Beshears et al. (2008), only after paying late fees video renters learn to return their videos on time (Fishman and Pope, 2007) and credit card account holders learn to pay their bills on time (Agarwal et al., 2007). In a similar vein, sex workers begin using condoms only when the information about the use of condoms is provided by other trained sex workers (Rao and Walton, 2004). More complex feedback effects (e.g. from choices to emotions, anxiety, temptation, etc.), however, can require some sort of expert advice in order to be learned. One class of expert advice consistent with our framework is psychological therapy (such us Cognitive Behavioral Therapy) which has been shown to be an effective device in helping people to learn how to cope with stress, anger, fear, anxiety or low motivation by changing their response to a situation (emotion-focused problem) or by changing the environment (problem-focused coping) (Lazarus, 1984; Hawton et. al, 1989). More precisely, behavioral therapies that teach cue-avoidance to addicts have shown to be successful without providing new information (Bernheim and Rangel, 2007). As argued by Baron (2006), emotions are (partly) under people's control and individuals can "induce or suppress emotions in themselves almost on cue."

A natural question that arises is what types of institutions can provide the capacities needed to internalize the feedback effect. After all, as Mullainathan (2006) argues, good institutions also help to reduce problems that arise within a person. An example of such institution is “The Improving Access to Psychological Therapies” programme (IAPT) initiated in 2006 in the UK. IAPT aims at offering evidence based psychological therapies and psychological support to a wide range of the population. Layard et al. (2008) argue that IAPT does not only improve individual wellbeing but also social wellbeing by reducing other public costs associated with psychological disorders (e.g. welfare benefits and medical costs) and increasing revenues (e.g. taxes from return to work and increased productivity).

To conclude with this section, it is important to highlight that some standard policies that have always thought to be (at least weakly) welfare improving, may fail in our framework. For instance, it easy to construct examples of distinguishable decision problems (which we remind the reader have characteristics similar to a two person game) where, in a BDP, providing more information or more opportunities to a the decision maker may make her worse-off.

Two such examples are constructed below.

Example 4. *More information may make the decision-maker worse-off*

Consider a decision problem with payoff relevant uncertainty, with two states of the world $\{\theta_1, \theta_2\}$ where preferences are

$\theta_1 \rightarrow$

	p_1	p_2	p_3
a_1	-1	0	0
a_2	0	3	$\frac{1}{2}$
a_3	1	4	1

$\theta_2 \rightarrow$

	p_1	p_2	p_3
a_1	1	4	1
a_2	$\frac{1}{2}$	3	0
a_3	0	0	-1

where $\pi(a_i) = p_i$. Suppose, to begin with, the decision-maker has to choose before uncertainty is resolved. At the time when she makes the decision, the individual attaches a probability $\frac{1}{2}$ to θ_1 and $\frac{1}{2}$ to θ_2. In this case, expected payoff matrix is

	p_1	p_2	p_3
a_1	0	2	$\frac{1}{2}$
a_2	$\frac{1}{4}$	3	$\frac{1}{4}$
a_3	$\frac{1}{2}$	2	0

It follows that the unique BDP outcome is (a_2, p_2) with expected payoff 3.

Next, suppose that the decision-maker knows with probability one the true state of the world. Then, when the state of the world is θ_1, a_3 strictly dominates all other actions and the unique BDP outcome is (a_3, p_3) with payoff 1 and when the state of the world is θ_2, a_1 strictly dominates all other actions and the unique BDP outcome is (a_1, p_1) with payoff 1. Therefore, the decision-maker is worse-off with more information[18][19].

Example 5. *More actions may make the decision-maker worse-off*

Consider first a situation where the payoff table is

	a_1	a_2
a_1	-1	0
a_2	0	3

where $\pi(a_i) = p_i$. The outcome of the BDP is (a_2, p_2) with payoff 3. Now, expand the set of choices so that the following payoff table represents the decision problem

	a_1	a_2	a_3
a_1	-1	0	0
a_2	0	3	1
a_3	1	4	2

where $\pi(a_i) = p_i$. Note that the unique BDP outcome is (a_3, p_3) with payoff $2 < 3$. This means that although the action set of the decision-maker has been expanded so that (a) the ranking of existing actions is unaffected and (b) the new action strictly dominates all existing actions, the individual is made worse-off.

6 Psychological and Philosophical grounds for the model

Our framework relies on three key conceptual ideas. First, there is a feedback effect from actions to preference parameters that may not be fully internalized by the decision maker. Second, the individual's best interest is defined in the space of outcomes only when the feedback effect is internalized. Third, the individual always chooses what she judges best for her. In this section, we briefly review part of the literature in Social Psychology and the Moral Philosophy that supports these conceptual ideas.

[18] Note that in this example we are referring only to information that solves the uncertainty about exogenous states of the world. Our statement "the decision-maker is worse-off with more information" would not be right in the case in which additional information helps the decision-maker to learn about the feedback.

[19] This result is consistent with Carrillo and Mariotti's (2000) results, although we don't need a dynamic model with time-inconsistent preferences.

On the Social Psychology front, there is extensive work led by Albert Bandura who views human functioning as the product of a dynamic interplay of personal, behavioral, and environmental influence. Bandura points out that the way in which people interpret the results of their own behavior informs and alters their environments and personal factors which, in turn, inform and alter subsequent behavior through an "environmental feedback effect." He labelled this view “reciprocal determinism” (see e.g. Bandura, 1986, 1997, 2001).

On the philosophical front, the state of acting against one’s better judgment has been studied since Plato and it has been labelled “Akrasia[20]”. In the dialogue, Socrates sustains that “akrasia” is an illogical moral concept: “no one goes willingly toward the bad” (358d). If a person examines a situation and decides to act in the way he determines to be best, he will actively pursue this action. In accordance to the normative principle advocated in this paper, Socrates postulated that an all-things-considered assessment of the situation will bring full knowledge of a decision’s outcome and worth linked to well-developed principles of the good. Donald Davidson (1980), a contemporary American philosopher, argued that when people act in “akrasia” they temporarily believe that the worse course of action is better, because they have not made an all-things-considered judgment, but only a judgment based on a subset of possible considerations.

Our characterization of a standard decision maker is close to the concept of personal autonomy studied in the literature of Philosophy (Friedman, 2003; Dworkin, 1988; Elster 1983) and Psychology (Ryan and Deci, 2006)[21]. As argued by Friedman (2003) “autonomous behaviour is based on the deeper wants and commitments of the person, is partly caused by her reflections on and reaffirmations of them.[...] for choices and actions to be autonomous, the choosing and acting self as the particular self she is must play a role in determining them [...] When wants and desires lead to choice or action without having been self-reflectively endorsed by the person, the resulting choices and actions are not autonomous.” (pp. 4). In a similar vein, Elster (1983) defines autonomous preferences (or desires) as those “that have been deliberately chosen, acquired or modified –either by an act of will or by a process of character planning” (pp. 22). When autonomously functioning, people are more deeply engaged and productive, generating human capital and welfare (Woo, 1984). Ekstrom (2005) and Kernis and Goldman (2005) stress that autonomous acts proceed from one’s core self, representing those preferences and values that are wholeheartedly endorsed. As Ryan and Deci (2006) illustrate, a man who decides to "have another drink" would not be autonomous unless, in reflecting on this motive, he could fully endorse it.

[20] In ancient Greek: Akrasia means “lacking command” (over oneself)

[21] Self-determination theory (SDT) provides a comprehensive picture of the importance of autonomy for well-being. Autonomy is considered a basic psychological need (see Ryan and Deci, 2006)

7 Conclusion

Positive behavioral economics models challenge the way in which welfare economics has been conducted over the past six decades. How can choices of an individual remain as foundations for compelling welfare standards if they do not reveal what is best for the individual?

We have provided a theoretical framework to address this question. In our view, this paper contributes to normative and positive behavioral economics in the following ways. First, our framework unified seemingly disconnected models in the literature, from more recent positive behavioral economics models to older models of adaptive preferences. The generality of our framework allowed us to derive key properties of behavioral models and to compare them with standard economics models. Using the usual tools of revealed preference theory, we have provided a full axiomatic characterization of behavioral decisions and shown that standard and behavioral decision problems have different testable implications. Second, we have proposed a novel choice experiment that allows, on the basis of choice data alone, to infer the divergence between choice and welfare. Notably, it is possible to infer whether an individual could be better-off by choosing an available alternative that she has never chosen. Third, we have provided a novel equilibrium existence result in pure actions without complete and/or transitive preferences. A result like that is important on its own, since incomplete and non-transitive preferences are a common token in behavioral economics models. Fourth, we have shown that behavioral and standard decisions are, typically, distinguishable from each other. Finally, we have offered theoretical grounds for soft-libertarian policies that aim at helping the individual to improve decisions by learning how to cope with own psychological states or, more generally, any dimension of preferences that the individual may struggle to internalize. Far from being new, this type of interventions are at the core of other disciplines, notably clinical psychology.

Further research includes: (a) if different behavioral decision problems, associated with the same underlying standard decision problem, have distinct testable implications, (b) examine the distinction between SDP and a BDP in a N-person strategic context. On the empirical front, the challenge is to uniquely identify the decision making process itself.

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Appendix

Proof of Proposition 4: Existence Result

Recall that the preferences of the decision-maker is denoted by $\succeq$ a binary relation ranking pairs of decision states in $(A \times P) \times (A \times P)$. As the focus is on incomplete preferences, in this section, instead of working with $\succeq$, we find convenient to specify two other preference relations, $\succ$ and $\sim$. The expression $\{(a,p), (a',p')\} \in \succ$ is written as $(a,p) \succ (a',p')$ and is to be read as "(a,p) is strictly preferred to (a',p') by the decision-maker". The expression $\{(a,p), (a',p')\} \in \sim$ is written as $(a,p) \sim (a',p')$ and is to be read as "(a,p) is indifferent to (a',p') by the decision-maker". Define

$$(a,p) \succeq (a',p') \Leftrightarrow either\ \ (a,p) \succ (a',p')\ or\ \ (a,p) \sim (a',p').$$

Once $\succeq$ is defined in this way, the results obtained in the preceding sections continue to apply. In what follows, we do not require either $\succeq$ or $\succ$ or $\sim$ to be transitive

Schofield (1984) shows that if action sets are convex or are smooth manifolds with a special topological property, the (global) convexity assumption made by Shafer and Sonnenschein (1975) can be replaced by a "local" convexity restriction, which, in turn, is equivalent to a local version of acyclicity (and which guarantees the existence of a maximal element).

However, here, as action sets are not necessarily convex and are allowed to be a collection of discrete points, Schofield's equivalence does not apply.

Suppose $\succ$ is

(i) acyclic i.e. there is no finite set $\{(a^1, p^1), ..., (a^T, p^T)\}$ such that $(a^{t-1}, p^{t-1}) \succ (a^t, p^t)$, $t = 2, ..., T$, and $(a^T, p^T) \succ (a^1, p^1)$, and

(ii) $\succ^{-1}(a, p) = \{(a', p') \in A \times P : (a, p) \succ (a', p')\}$ is open relative to $A \times P$ i.e. $\succ$ has an open lower section[22].

Suppose both A and P are compact. Then, by Bergstrom (1975), it follows that S is non-empty.

Define

$$a \succ_p a' \Leftrightarrow (a, p) \succ (a', p).$$

The preference relation $\succ_p$is a map, $\succ: P \to A \times A$. If $\succ$ is acyclic, then for $p \in P$, $\succ_p$is also acyclic. If $\succ$ has an open lower section, then $\succ_p^{-1}(a) = \{a' \in A : a \succ a'\}$ is also open relative to A i.e. $\succ_p$ has an open lower section. In what follows, we write $a' \notin \succ_p (a)$ as $a \not\succ_p a'$ and $a' \in \succ_p (a)$ as $a' \succ_p a$.

Define a map $\Psi : P \to A$, where $\Psi(p) = \{a' \in A : \succ_p (a') = \varnothing\}$: for each $p \in P$, $\Psi(p)$ is the set of maximal elements of the preference relation $\succ_p$.

We make the following additional assumptions:

(A1) A is a compact lattice;

(A2) For each p, and a, a', (i) if $\inf(a, a') \not\succ_p a$, then $a' \not\succ_p \sup(a, a')$ and (ii) if $\sup(a, a') \not\succ_p a$ then $a' \not\succ_p \inf(a, a')$ (quasi-supermodularity);

(A3) For each $a \geq a'$ and $p \geq p'$, (i) if $a' \not\succ_{p'} a$ then $a' \not\succ_p a$ and (ii) if $a \not\succ_p a'$ then $a \not\succ_{p'} a'$ (single-crossing property)[23]

(A4) For each p and $a \geq a'$, (i) if $\succ_p (a') = \varnothing$ and $a' \not\succ_p a$, then $\succ_p (a) = \varnothing$ and (ii) if $\succ_p (a) = \varnothing$ and $a \not\succ_p a'$, $\succ_p (a') = \varnothing$ (monotone closure).

Assumptions (A2)-(A3) are quasi-supermodularity and single-crossing property defined by Milgrom and Shannon (1994).

Assumption (A4) is new. Consider a pair of actions such that the first action is greater (in the ussual vector ordering) than the second action. For a fixed p, suppose the two

[22] The continuity assumption, that $\succ$ has an open lower section, is weaker than the continuity assumption made by Debreu (1959) (who requires that preferences have both open upper and lower sections), which in turn is weaker than the assumption by Shafer and Sonnenschein (1975) (who assume that preferences have open graphs). Note that assuming $\succ$ has an open lower section is consistent with $\succ$ being a lexicographic preference ordering over $A \times P$.

[23] For any two vectors $x, y \in \Re^K$, the ussual component-wise vector ordering is defined as follows: $x \geq y$ if and only if $x_i \geq y_i$ for each $i = 1, .., K$, and $x > y$ if and only if both $x \geq y$ and $x \neq y$, and $x \gg y$ if and only if $x_i > y_i$ for each $i = 1, .., K$.

actions are unranked by $\succ_p$. Then, assumption (A4) requires that either both actions are maximal elements for $\succ_p$or neither is.

The role played by assumption (A4) in obtaining the monotone comparative statics with incomplete preferences is clarified by the following examples. There preferences and action sets in each example satisfy assumptions (A1)-(A3). However, assumption (A4) fails to hold in either example.

Example 1: ($\Psi(p)$ needn't be a lattice.)

P is single valued and A is the four point lattice in $\Re^2$

$$\{(e,e),(f,e),(e,f),(f,f)\}$$

where $f > e$. Suppose that $(f,f) \succ (e,e)$ but no other pair is ranked. Then, Ψ consists of $\{(f,e),(e,f),(f,f)\}$ clearly not a lattice. Note that in this case, preferences satisfy acyclicity and quasi-supermodularity (and trivially, single-crossing property). However, preferences do not satisfy monotone closure: $(f,e) \geq (e,e)$, with $\succ((f,e)) = \emptyset$ and $(e,e) \succeq (f,e)$, but $\succ((e,e)) \neq \emptyset$.

The preceding example demonstrates that without the additional assumption of monotone closure, quasi-supermodularity on its own cannot ensure that the set of maximal elements of $\succ$ is a sublattice of A even when $\succ$ is acyclic. The example also demonstrates that $\succ$ can be acyclic without necessarily satisfying monotone closure and therefore, the two are distinct conditions on preferences.

Example 2: (No increasing selection from $\Psi(.)$.)

$P = \{p, p'\}$, $p < p'$, and A is the five point lattice in $\Re^2$

$$\{(e,e),(f,e),(e,f),(f,f),(g,g)\}$$

where $g > f > e$. Preferences are such that: (i) $(g,g) \succ_p (f,f) \succ_p (e,e)$, $(f,e) \succ_p (e,e)$, $(e,f) \succ_p (e,e)$, $(f,e) \succ_p (e,f)$, $(f,e) \succ_p (g,g)$, $(e,f) \succ_p (g,g)$ but the pairs $\{(f,e),(f,f)\}$ and $\{(e,f),(f,f)\}$ aren't ranked by $\succ_p$; (ii) $(g,g) \succ_{p'} (f,f) \succ_{p'} (e,e)$, $(f,e) \succ_{p'} (e,e)$, $(e,f) \succ_{p'} (e,e)$, $(e,f) \succ_{p'} (f,e)$, $(f,e) \succ_{p'} (g,g)$, $(e,f) \succ_{p'} (g,g)$ but the pairs $\{(f,e),(f,f)\}$ and $\{(e,f),(f,f)\}$ aren't ranked by $\succ_{p'}$. Note that in this case, both $\succ_p$ and $\succ_{p'}$ satisfy acyclicity (but not transitivity), quasi-supermodularity (because both $\succ_p$ and $\succ_{p'}$ are irreflexive) and the single-crossing property. It follows that $\Psi(p) = \{(f,e)\}$ and $\Psi(p') = \{(e,f)\}$ (i.e. for both p and p' the set of maximal elements is a singleton and hence, trivially a lattice). Therefore, $\Psi(.)$ does not admit an increasing selection. Observe that neither $\succ_p$ nor $\succ_{p'}$satisfy monotone closure: $(f,f) \geq (f,e)$, with $\succ_p((f,e)) = \emptyset$ and $(f,f) \succeq_p (f,e)$, but $\succ_p((f,f)) \neq \emptyset$ and $(f,f) \geq (e,f)$, with $\succ_{p'}((e,f)) = \emptyset$ and $(f,f) \succeq_{p'} (e,f)$, but $\succ_{p'}((f,f)) \neq \emptyset$.

The preceding example demonstrates that with incomplete but acyclic preferences, quasi-supermodularity and single crossing on their own cannot ensure an increasing selection from the set of maximal elements.

The following result shows that assumptions (A1)-(A4), taken together, are sufficient to ensure monotone comparative statics with incomplete preferences:

Lemma : Under assumptions (A1)-(A4), each $p \in P$, $\Psi(p)$ is non-empty and a compact sublattice of A where both the maximal and minimal elements, denoted by $\bar{a}(p)$ and $\underline{a}(p)$ respectively, are increasing functions on P.

Proof. By assumption, for each p, $\succ_p$ is acyclic, $\succ_p^{-1}(a)$ are open relative to A and A is compact. By Bergstrom (1975), it follows that $\Psi(p)$ is non-empty. As Bergstrom (1975) doesn't contain an explicit proof that $\Psi(p)$ is compact, a proof of this claim follows next. To this end, note that the complement of the set $\Psi(p)$ in A is the set $\Psi^c(p) = \{a' \in A : \succ_p (a') \neq \emptyset\}$. If $\Psi^c(p) = \emptyset$, then $\Psi(p) = A$ is necessarily compact. So suppose $\Psi^c(p) \neq \emptyset$. For each $a' \in \Psi^c(p)$, there is $a'' \in A$ such that $a'' \succ_p a'$. By assumption, $\succ_p^{-1}(a'')$ is open relative to A. By definition of $\Psi(p)$, $\succ_p^{-1}(a'') \subset \Psi^c(p)$. Therefore, $\succ_p^{-1}(a'')$ is a non-empty neighborhood of $a' \in \Psi^c(p)$ and it is clear that $\Psi^c(p)$ is open and therefore, $\Psi(p)$ is closed. As A is compact, $\Psi(p)$ is also compact. Next, it is shown that for $p \geq p'$ if $a \in \Psi(p)$ and $a' \in \Psi(p')$, then $\sup(a,a') \in \Psi(p)$ and $\inf(a,a') \in \Psi(p')$. Note that as $a' \in \Psi(p')$, $a' \succeq_{p'} \inf(a,a')$. By quasi-supermodularity, $\sup(a,a') \succeq_{p'} a$. By single-crossing, $\sup(a,a') \succeq_p a$. As $a \in \Psi(p)$, $\succ_p (a) = \emptyset$, and by monotone closure $\sup(a,a') \succeq_p a$ and $\succ_p (\sup(a,a')) = \emptyset$, it follows that $\sup(a,a') \in \Psi(p)$. Next, note that as $a \in \Psi(p)$, $a \succeq_p \sup(a,a')$. By single-crossing, $a \succeq_{p'} \sup(a,a')$ and by quasi-supermodularity, $\inf(a,a') \succeq_{p'} a'$. As $a' \in \Psi(p')$, $\succ_{p'} (a') = \emptyset$, and by monotone closure $\inf(a,a') \succeq_{p'} a'$ and $\succ_{p'} (\inf(a,a')) = \emptyset$, it follows that $\inf(a,a') \in \Psi(p')$. Therefore, (i) $\Psi(p)$ is ordered, (ii) $\Psi(p)$ is a compact sublattice of A and has a maximal and minimal element (in the usual component wise vector ordering) denoted by $\bar{a}(p)$ and $\underline{a}(p)$, and (iii) both $\bar{a}(p)$ and $\underline{a}(p)$ are increasing functions from P to A. ■

To complete the proof of Proposition 4, define a map $\Psi : A \times P \to A \times P$, $\Psi(a,p) = (\Psi_1(p), \Psi_2(a))$ as follows: for each (a,p), $\Psi_1(p) = \{a' \in A : \succ_p (a') = \phi\}$ and $\Psi_2(a) = \pi(a)$. By Theorem 2, $\Psi_1(p)$ is non-empty and compact and for $p \geq p'$ if $a \in \Psi_1(p)$ and $a' \in \Psi_1(p')$, then $\sup(a,a') \in \Psi_1(p)$ and $\inf(a,a') \in \Psi_1(p')$. It follows that $\Psi_1(p)$ is ordered and hence a compact (and consequently, complete) sublattice of A and has a maximal and minimal element (in the usual component wise vector ordering) denoted by $\bar{a}(p)$ and $\underline{a}(p)$ respectively. By assumption 1, it also follows that for each a, $\pi(a)$ has a maximal and minimal element (in the usual component wise vector ordering) denoted by $\bar{\pi}(a)$ and $\underline{\pi}(a)$ respectively. Therefore, the map $(\bar{a}(p), \bar{\pi}(a))$ is an increasing function from $A \times P$ to itself and as $A \times P$ is a compact (and hence, complete) lattice, by applying Tarski's fix-point theorem, it follows that $(\bar{a}, \bar{p}) = (\bar{a}(\bar{p}), \bar{\pi}(\bar{a}))$ is a fix-point of Ψ and by a symmetric argument, $(\underline{a}(p), \underline{\pi}(a))$ is an increasing function from $A \times P$ to itself and $\left(\underline{a}, \underline{p}\right) = \left(\underline{a}(\underline{p}), \underline{\pi}(\underline{a})\right)$ is also a fix-point of Ψ; moreover, $(\bar{a}, \bar{p})$ and $\left(\underline{a}, \underline{p}\right)$ are respectively the largest and smallest fix-points of Ψ.