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Abstract

This paper examines some of the consequences for economic theory of the replacement of binary personal preferences by non-binary personal preferences in an Arrow-Debreu society as in Debreu (1959), and reaches the conclusion that there is both much damage to existing theory and greater opportunity for providing formal explanations of such phenomena as discrimination, personal freedoms and power, among others, which are impossible to explain at a formal level on the basis of an economic theory that is founded on a choice theory that is based exclusively on binary relational personal preferences.

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1. Introduction

The Kanger-Sen formulation of rational choice theory, as in Sen (1991, 1997), is a *non-binary* relational logic based choice theory, of which the standard *binary* relational logic based choice theory, as in Debreu (1959), is a special case. And, this 'binary rational choice theory' is the foundation of the Arrow-Debreu model of 'binary economic theory', as in Debreu (1959).[1] If for each distinct person in society, the personal preference relations in Debreu (1959), which are binary in character, were to be replaced by non-binary personal preference relations, as in Sen (1991, 1997), then the resultant society is what I call a *Non-binary Personal Preferences based Society*, and the economic theory of such a society I shall call *Non-binary Economic Theory*. Non-binary economic theory is thus the theory of a society that has a finite number of persons, each with a distinct non-binary personal preference relation, and every person acts as a maximizer of his or her preference, as in Sen (1991, 1997).

In this paper, I first describe some of the essential features of such a non-binary economic theory and contrast it with the characteristics of the existing (binary) economic theory. Second, I deduce some implications of the non-binary economic theory for what parts of existing economic theory survive the intrusion of such non-binariness, and what parts do not. Third, I provide a substantive application of non-binary economic theory in the form of an explanation of a specific socio-economic phenomenon, that of racial discrimination, that has so far defied *formal* explanation. In my concluding remarks, I comment on the essential

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[1] Arrow's original paper in general equilibrium theory appeared in 1951, but it was formalized at a much greater level of generalization in his joint work with Debreu (1954), and its pristine form appeared in Debreu (1951). Certainly, there are many extensions of this economic theory, for example to include asymmetric information on the part of different persons, as in Akerlof (1970), just it has a great many applications, for example to international trade theory, as in Jones (1971).

role of non-binary economic theory in shedding light on significant aspects of health economics.

The Kanger-Sen theory is a *theory of maximization as a volitional act of choice by a person* in the particular sense that such an action is based on a non-binary relation of (weak) personal preference that is defined on a (finite) set of alternatives.[2] Non-binary economic theory is a theory of a society that has a finite number of such persons.

As I explain below, a distinguishing feature of existing economic theory is that the *formal* framework of analysis disallows any role to be played by distinctive identities of different persons in society, except in a very narrow sense. However, if the social issue under investigation involves an operational role assigned to interpersonal differences in the identities of distinct persons in a broader sense, in their respective personal acts of volitional choice, as for example in decision making that relates to hiring in labor markets or lending in credit markets, taking into account the racial characteristics of the employer or the employee or the borrower or the lender, then this necessarily involves departures from the standard reliance on *binary* relations of personal preference defined on the set of culmination outcomes in choice theory, and *inter alia* belongs to the domain of the non-binary economic theory, not to the field of existing binary economic theory. To see this, consider the following argument.

If the decision making process of each and every person in a finite society is based on distinct, respective binary relations of weak preference, R_i defined on a finite set S of alternative social states, then the *only basis* of interpersonal differences can be the *order of placement* of the elements of S by distinct persons. No *other* basis of interpersonal difference

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[2] Of course, the Kanger-Sen theory is only one form that non-binary rational choice theory can take, because the negation of a binary relational logic based rational choice theory can take many different forms, and thus does not imply a unique non-binary relational logic based theory of rational choice. Another example of a non-binary relational logic based rational choice theory is a theory of binary *meta-ranking* of a class of binary rankings of a set of alternatives.

is admissible under the requirement of *binariness* of the personal preference relation. For, if *any* tertiary considerations were to play a role, then, by definition, the personal preference relations would cease to be binary in nature, because something *external* to the mere pair-wise comparison of two objects would also play a material role in the expression of preference.

One implication of this argument is that the identity of a person in society, irrespective of whether it is by self perception or by social recognition, as being White, or Hispanic, or African American, or the gender of a person, as being male or female, or any status in society the person may or may not have, can simply play no role in the expression of individuality of the persons in formal models, otherwise the pure *pair-wise comparisonal* property of elements of S embodied in the binary relation would be violated. Nor can the *characteristic features* of the elements of the set S of alternatives be allowed to play any role in a theory of choice that is binary, because only the interpersonal differences in the order-of-placement of the elements of the set is rendered material by the binariness of their respective ranking relations, whereas any tertiary considerations that go beyond *interpersonal order-of-placement differences* are rendered irrelevant.

Impersonality is, however, by itself, the feature of binariness that lies at the heart of the deficiency of the formal methodological approach to choice theory as the foundation of economic theory, *if* the purpose is to explain identity-based disparate-interpersonal-treatment that is actually observed in reality, as noted by Arrow (1998) in an informal discussion of racial discrimination. And, his diagnosis – entirely correct – is that racial discrimination, which is impossible to ignore in reality, is also impossible to explain on the basis of existing economic theory, precisely because of its impersonal nature, when, in fact, the kind of formal explanation needed is such that it must exhibit an identity-based disparate-interpersonal-treatment phenomenon. But, this can be remedied, as I argue below, and a formal model of

racial discrimination or gender discrimination can, in fact, be formulated; however, that requires departure from the binary nature of the personal preference relations of the individuals in society, so that tertiary considerations can be formally accommodated in the theory.[3]

2. Some Conceptual Issues

If the identity of the actor engaged in the act of choice is of material consequence, or if the identity of an influencer – whether it be another person or social norms or perceived morality – is of direct, *constitutive* value to the act of choice, then a person is different from another person by a characteristic that is *exogenous* to the *element-ranking* feature of R_i defined on S. This implies that non-binariness must be embraced as the appropriate way to model the characteristics of the preferences of human beings who are engaged in their respective acts of choice, to get a grip on social, economic and political behavior in any society that has individuals who have distinctive characteristics that are material to the phenomena under investigation, such issues as gender and race. The formal framework that is suitable for the analysis of such issues is one in which the identity of the chooser matters, in the sense of Sen (1997).

To see the departure in a more formal approach, consider a model of a society whose members have *non-binary* personal preference relations R_i^V for each person $i = 1, \ldots, n$, defined on the set S and V is a background set on which R_i depends. In this case, $\forall x, y \in S: x R_i^V y$, means that person i finds x to be at least as good as y, where both x and y are from the set S of alternatives, *when conditions V prevail*. Of course, in the special case that

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[3] Moreover, the elements of S could be the culmination outcomes of personal actions, as is standardly the case in choice based on preference in economic theory in general, or they could be culmination outcomes *cum* processes that lead to the outcomes, but in the latter case the casualty would be that the property of strong monotonicity (or of local non-satiation) would not be defined. More on this presently, in the context of health economics.

$V = \emptyset$, R_i is binary, because in this case the background set V is rendered irrelevant to the choice exercise.[4] Further, define

$$M(S, R_i^V) = \{x | x \in S \ \& \sim[\exists y \in S : (y P_i^V x)]\},$$

where $\forall x, y \in S : x P_i^V y \leftrightarrow [x R_i^V y \ \& \sim (y R_i^V x)]$, and P_i^V refers to strict preference. Here $M(S, R_i^V)$ is the *maximal set* of un-dominated elements of S, where R_i^V is a binary relation of weak preference that is a quasi-ordering (reflexive and transitive, though not necessarily complete), and V is a background set on which R_i is dependent. In general, $M(S, R_i^{V_1}) \neq M(S, R_i^{V_2})$, if $V_1 \neq V_2$, so that a variation in the background set on which the binary relation is dependent induces a change in the implied maximal set itself. It is precisely the variation in the background set on which the personal binary relation is dependent that, in general, implies a variation in the personal maximal sets that are predicated on the *underlying non-binary relation* R_i^V. In some instances, the background set could simply be a person, the influencer, who may or may not be the mazimizer.

3. Menu Dependence, Revealed Preference and Personal Utility Functions

The background set on which the binary relations of weak personal preference is dependent can manifest itself in the form of distinct menus being available to the same person, and thereby influence the choice as the person's volitional act of maximization. Since in general,

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[4] In addition to R_i defined on S being binary (Axiom **B**), in standard choice theory it is assumed that it is (i) *Reflexive*, (ii) *Complete* and (iii) *Transitive*, so that it *Completely Orders S* (Axiom **C**). An additional restriction is placed on the set S so that any element $x \in S$ is a finite-dimensional non-negative real vector that represents a combination of the quantities of distinct commodities (in physical units per unit time) that could be consumed by person i .(Axiom **R**). Two additional restrictions are imposed on this framework for it to be the binary relational choice theoretic model. First, *Strong Monotonicity* (Axiom **M**): $\forall x, y \in S : (x \geq y) \rightarrow (x P_i y)$, where $(x P_i y) \leftrightarrow [(x R_i y) \& (y R_i x)]$. Second, *Convexity* (Axiom **V**): The set $R_i(y) = \{x | x \in S \ \& \ x R_i y, \forall y \in S\}$ is convex. It can also be assumed, if one wishes to give a real-valued numerical representation called a utility function to R_i defined on S, that the set $R_i(y)$ and the set $R_i'(y) = \{x | x \in S \ \& \ y R_i x, \forall y \in S\}$ are both closed, and this is called the *Continuity Axiom*, but this last requirement is necessary neither for the theory of personal binary preference maximization nor for the existence of general equilibrium in Debreu (1959). Axioms **B**, **C**, **R**, **M**, and **V** are sufficient for the existence of a Walrasian equilibrium of an exchange economy. Actually, Kelsey and Yalcin (2007) drop the completeness requirement and still obtain the general equilibrium existence result.

$$M(V_1, \ R_i) \neq M(V_2, \ R_i), \text{if } V_1 \neq V_2,$$

where $V_1, \ V_2 \subseteq S$ can be interpreted as distinct menus from which person i contemplates making a choice, the dependence of the binary personal preference relation R_i on distinct menus renders the formal framework non-binary, since the sets of elements being ranked by this person are non-identical. For example, as Sen (1997) argues most forcefully, there is nothing irrational about $\{x\} = M(\{x, y\}, \ R_i)$ and simultaneously $\{y\} = M(\{x, y, z\}, \ R_i)$, and yet this type of menu dependence of a binary relation of preference violates the Weak Axiom of Revealed Preference, or WARP as it is commonly known.

Menu dependence not only entails non-binary personal preferences, but a significant casualty is also the entire *Theory of Revealed Preference*, including the role played by WARP. On further details relating to this matter, see Sen (1993). The implications appear even more serious in terms of damage suffered by economic theory if one recalls in how many theorems WARP has been invoked, if personal preferences in society are actually non-binary.

Moreover, regardless of whether non-binariness of personal preferences arises due to the operational significance of interpersonal differences in the identity of the distinct persons in society, or whether it emerges from menu dependence, or if it surfaces because the characteristics of the elements of the set being ranked by the person have features that are material to the ranking by this person rather than by another person, in all of these cases there appear quite forcefully some serious conceptual problems in the formal analysis of such a society (with non-binary personal preferences). For example, what is a personal utility function if preferences are non-binary? It cannot be the one in Debreu (1959). Nor can it be the one in Majumdar and Sen (1976), because both contributions deal with binary preferences. Numerical representation of preferences is certainly a loss in replacing binary by

non-binary preferences. But, social characteristics and group features can still be given numerical representation.

4. Theories of Value

Production theory in economics remains intact, however, both in the Sraffa (1960) framework (that disallows the use of counterfactual information), and in the informationally distinct (in fact, strictly richer) framework of the production side of the Arrow-Debreu Walrasian, competitive general equilibrium model, as in Debreu (1959). The Arrow-Debreu model's usefulness as a *theory of value* does suffer damage if personal preferences are allowed to be non-binary, because there are implied problems associated with the non-existence of a general equilibrium arising from non-existence of excess demand functions.

In spite of this damaging conclusion for the non-existence of equilibrium in the Arrow-Debreu model if personal preferences are non-binary, it is important to remember that the standard model was never meant to explain social or political phenomena, but was intended to provide an axiomatic basis of determination of prices in a market economy. In that important task, it does succeed. The problem arises when this model is used for other purposes for which it was never intended, especially for analyzing issues that involve considerations of menu variation for the same person or in dealing with matters of materially-distinct identities of persons, among other influences that induce non-binariness of personal preferences in society.

Srafffa's (1960) theory of value remains unaffected by the inclusion of non-binariness of preferences, however, because, as it is, preferences play no role in his theory of the determination of relative commodity prices or of the distribution of income between workers and non-workers. Thus, numerical measurability (usually ratio-scale) continues to be applicable for the description of price determination and income-distribution determination –

as in the form of *revelation* or in the manner of *formation* – in the markets for different commodities that are produced by labor and commodities, but this is true only of Sraffa's theory of value, not of the Arrow-Debreu theory of value. This is a serious indictment of the Arrow-Debreu general equilibrium model because with non-binary personal preferences this model ceases to provide a basis of a theory of value.

5. Expected Utility Theory and Game Theory

It would be useful to identify the domains of decision making over which persons would (a) wish to deliberately engage *exclusively* in making pair-wise comparisons and (b) declare an alternative to be at least as good in *every* such pair-wise comparison. These behavioral assumptions characterize both the expected utility hypothesis of the descriptive type, and also are attributes of the basis of choice by every player in game theory. In light of the domains over which players engage in non-binary acts of choice, explanations of this latter form of behavior would necessarily lie *outside* the scope of present-day game theory.

The theory of games or the theory of game-forms with players with non-binary preferences has not been written yet. For example, if constitutive role is assigned to the identities of the persons in a prisoners' dilemma as identifiable members of a society with social norms (for example those who snitch on others get killed in prison), and such information is also common knowledge, then the augmented-Nash outcome of the game need no longer be Pareto sub-optimal at all. Here again, some feature external to the binary choice process is taken into account by each player, thereby rendering the personal preference basis non-binary.

6. Constitutive Value of the Identity of the Chooser in a Person's Act of Choice

It is futile, then, to seek an explanation for racial discrimination or of gender, age or tribal discrimination or any other *identity-based* disparate-social-treatment theory from a binary-relation-based personal preference structure of a society. In fact, seeking to answer the

question, "What does economics have to say about racial discrimination?" Arrow (1998)

argues most forcefully, and concludes,

> *Enough has been said to suggest that market-based theories give an inadequate account of the effects of racial discrimination on economic magnitudes and the effects of the economic system on racial discrimination.* It is increasingly recognized that *many social interactions with economic implications are not mediated through a depersonalized market, but rather through the cumulative effect of individual choices. … The main point is that personal interactions occur throughout this process, and therefore there is plenty of room for discriminatory beliefs and preferences to play a role which would be much less likely in a market subject to competitive pressures.* The network model seems most appropriate for the labor market, and perhaps less so for the housing, automobile, and credit markets. But in all of these, each transaction is a social event. The transactors bring to it a whole set of social attitudes which would be irrelevant in the market model. Models of racial discrimination in which all racial attitudes are expressed through the market will get at only part of the story. At each stage, direct social transactions unmediated by a market play a role. Even the market manifestations will be altered by these direct social influences. (pp. 94-98).[5],[6]

It is important to note that Arrow (1998), in his analysis of discrimination, supposes

'rational choice theory' to mean that individual actors act rationally by maximizing according

to a complete ordering,

> within the constraints imposed by preferences, technology, and beliefs, and by the institutions which determine how individual actions interact to determine outcomes. Further, the beliefs are themselves formed by some kind of rational process. By economic theory, we mean that in some sense, markets are the central institution in which individual actions interact and that other institutions are of negligible importance. (p. 94).

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[5] Emphases added.

[6] Arrow's (1998) penetrating justifications of his claims are enlightening. He states, "The theoretical picture of a market is one of *impersonal* exchange. … There is no particular relation between a supplier and a demander; that is, a supplier is indifferent about supplying one demander or another, and vice versa. This is not a bad description of highly organized exchanges, such as securities and futures markets, but hardly complete for even most commodity markets, let alone the labor and credit markets. Suppliers and demanders have direct personal relations … Certainly, *employment of labor involves direct personal relations between employee and employer* (or the latter's agents) as well as among employees. Similarly, *credit relations* other than those represented by marketable securities *have typically required direct personal interaction between debtor and financial institution.* … Most analysts, following Becker (1957), add to the usual list of commodities some special disutility which Whites attach to contact with blacks, taste-based discrimination. … The trouble with these explanations is that they contradict in a direct way the usual view of employers as simple profit-maximizers. … There are at least two objections to this line of analysis. One is that introducing new variables easily risks turning the "explanation" into a tautology. … Perhaps more serious is the neglect of Darwinian principles. Presumably the population of employers is not uniform in its discriminatory tastes. Then, under the usual assumption of constant (or increasing) returns to scale, competition would imply the elimination of all but the least discriminatory employers. If there are any non-discriminatory employers, they would drive out the others. A further objection to the hypothesis that racial wage differentials arise from employer discrimination is that large corporations hire a major fraction of the labor force. Attributing taste to impersonal entities is a hypothesis of dubious usefulness. It is hardly in the stockholders' interests to discriminate under the postulated condition, and competition in the capital market should be effective in eliminating discrimination. Finally, the hypothesis of employer discrimination does not at all explain segregation by occupation. An alternative hypothesis is that labor market discrimination is due to discriminatory tastes of other employees. In the case of large corporations, for example, it would be those of the executives, although other scenarios have been advanced. But then it is easy to see that in simple cases, the natural equilibrium would be segregation within an industry-that is, firms with either all black or all White labor forces." (pp. 94-96, emphases added).

In spite of tremendous flexibility in the formation of beliefs, once formed, in Arrow's conception personal preferences in society are still represented by binary relations.

7. Non-binary Basis of Explanation of Identity-based Discrimination

In additional to Arrow's (1998) critique of the approach to taste-based explanation of discrimination in Becker (1957, 1971), there is also the problem that Becker's argument is identity-based, but has been conducted in a framework that is unsuitable for the investigation, since it assumes that personal preferences that characterize all members of society are entirely binary, thereby banishing from the framework any marks of individual identification such as gender or race. To see this, recall that, as noted in Section 2, in general, $M\left(S, R_i^{V_1}\right) \neq M\left(S, R_i^{V_2}\right)$, if $V_1 \neq V_2$, so that a variation in the background set on which the binary relation is dependent induces a change in the implied maximal set itself.

If V_1 represents a White employer and V_2 represents an African American employer, then a theory of racial discrimination immediately follows, insofar as the maximal sets in the hiring decision out of the same set S of candidates need not be the same for the White employer as it would be for an African American employer. Moreover, contrasted with the inadequacy of standard binary-choice-theory-based explanations that Arrow refers to, *incomplete segregation*, both within an industry and across occupations, would emerge in the collective outcome, if non-binariness is embraced in the choice-theoretic formal framework. Thus the problem of complete segregation in the form of exhibiting only-black firms or only-White firms in an industry, which is necessarily implied by binary economic theory, is resolved by reliance on non-binary economic theory.

This would explain the stylized fact of a higher unemployment rate among African Americans than among Whites in the U.S.A. Of course, a similar argument can be developed

for males versus females, to explain the earnings differential between males and females that has been observed in most of the world.

8. Positive Constitutive Value of Comprehensive Outcomes

The set S of alternative social states can itself be given narrower or wider interpretations. Typically, culmination outcomes of an action are the elements of this set in binary economic theory. But, there is nothing in the very language of choice theory that prohibits its elements from being comprehensive outcomes that are inclusive of the process by which a final outcome is reached. If so interpreted, then the choice act of a person involves an act of (i) relative evaluation of alternative actions prior to the choice act, and (ii) included in that evaluation are both (a) positive constitutive value attached to the final outcome of an action, as in a pure consequentialist evaluation, and (b) positive constitutive value attached to the means by which the final outcome arises. Sen (2000) explores such a blend of both consequentialism and instrumentalism in the context of practical reason, where rationality is construed very broadly as bringing reason to bear on the choice of one's actions, and having the person take responsibility for the consequences of her actions, while taking into account the over-all circumstances surrounding a person's act of making a choice. An example is that a person's death is declared involuntary manslaughter if a car's brakes fail versus it being declared premeditated murder if a person makes a plan and executes it by a hit-and-run car accident.

It must be kept in mind, though, that if the set on with the preference relation is defined is construed more broadly to include comprehensive outcomes, inclusive of processes and identities of the individuals involved in the processes that lead to the culmination outcomes, then the strong monotonicity property is not defined, and without this property being satisfied, neither excess demand functions nor a Walrasian general equilibrium will, in general, exist. Quite clearly, non-existence of general equilibrium poses a very serious

problem for such a model to serve the purpose of a theory of value. However, as already noted, Sraffa's (1960) theory of value remains entirely unaffected regardless of whether personal preferences are binary or non-binary.

9. Concluding Remarks

In the evaluation of alternatives available to a person in many circumstances, operationally-significant departures from binary personal preferences of members of society arise because evaluations are predicated on considerations external to purely pair-wise ranking exercises inherently dictated by binary personal preferences. Consider the case of cardiac stents (x) for patients with the appropriate risk profile, or defibrillators (y), or cardiac coronary angiography as the basis of treatment determination (z), as possible alternatives from which a person and her doctor are considering the maximal element. This is hardly a case of choice based on binary preference for a person whose risk profile does not rule out any one of the three alternatives outright. Moreover, the decision is based on a considered interaction between two persons, patient i and doctor j, so that the formalization of the maximization problem of person i would take the form $M(\{x, y, z\}, R_i, j)$, with the clear understanding that the set {x, y, z} is not a collection of culmination outcomes, but rather of procedures or processes that are the objects of personal choice. This class of problems belongs squarely to the domain of non-binary choice theory. A great many occasions arise in decision making in health economics that involve such intricacies, and to jettison such features of reality from formal analysis, including those related to speed of post-op recovery (and thus of freedom associated with post-op mobility), would be tantamount to taking on board inadequacies in formalization of the type Arrow (1998) has made reference to in his discussion of racial discrimination, though for reasons distinct from the one of personalization to which he attributes the problem.

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There is much work that remains to be done here. Choices of such kind as arise in the example of health economics discussed above involve process-valuation at the constitutive level that goes beyond attaching value only to culmination outcomes far more than choice problems do in the case of deciding on the consumption of commodities such as bread, butter or haircuts, simply because issue of life and liberty are also involved in the former exercise in an operationally significant manner, and these are not matters that can be handled adequately by a binary framework of personal preferences.[7]

Concepts such as *liberty* of a type that is based on interpersonal differences over operationally-valued domains of influence would also fall beyond the reach of binary relations. Sen (2002), in his revised Arrow Lectures, has formalized these issues of freedoms using *non-binary relational logic*, with special reference to the opportunity-aspect of personal freedom and the process-aspect of personal liberty, which is more dominant in the literature on rights. Also, some types of abridgment of individual liberty can be captured if a role is allowed to be played in formal models by a person who acts as a freedom restrictor (such as a prison guard) and influences the act of choice of another person (the prisoner). In such a manner, concepts such as *power* arising from interpersonal differences over operationally-valued domains of influence can also be examined, but this would also require eschewing formal models based on binary personal preferences.

I also wish to clarify that replacing binary personal preference relations by non-binary ones in the model of a society must not be construed to be a license to bring absolutely anything and everything, including aliens and extra-terrestrials, into the domain of discourse. There is no need to depart from the principle of maximization as a volitional act of personal choice, but there is benefit that comes from increasing the scope and reach of economic

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[7] It is thoroughly unclear what strong monotonicity would mean if the set on which the ranking relations is defined in decision making in health economics is not merely the set of commodity bundles but rather a set of treatment processes inclusive of the culmination outcomes.

theory by enlarging the domain of considerations in formal analysis through the inclusion of those tertiary features that are particularly relevant to the social phenomena of interest, even if they are exogenous to the pair-wise comparisonal feature of a person's choice.

It is worth emphasizing that, in spite of the non-existence of equilibrium in the Arrow-Debreu model if personal preferences are non-binary, this standard model was intended to provide an axiomatic basis of determination of prices in a market economy, which it accomplishes admirably. Problems arise when this model is used for *other* purposes for which it was never intended, especially for analyzing issues that involve considerations of menu variation for the same person, when the source of variation for a personal maximal set is the identity of the chooser in a society, or the influence on personal choice is the set of norms of behavior in society.

Materially-personalized interaction in social, economic and political spheres of human activity is wide-spread. And, as the argument developed in this paper indicates, such phenomena are not amenable to formalization in a choice theoretic framework that is binary in character. There is, thus, much to be gained by bridging the existing gap between such real-world phenomena and their theoretical explanations, by employing non-binary economic theory. Non-binary relational logic can, therefore, play a very useful role in explaining social, economic and political phenomena in formal models that are methodologically capable of utilizing information typically processed and utilized by human beings in their routine *rational* acts of *non-binary* choice.

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