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Adam Karbowski,
Warsaw School of Economics,
Warsaw, Poland,
E-mail:
adam.karbowski@sgh.waw.pl

DISCUSSION ON THE SOCIAL RATE OF DISCOUNT: FROM SEN TO BEHAVIOURAL ECONOMICS

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ABSTRACT. This survey paper discusses the links between (1) research done by Amartya K. Sen on the social rate of discount and (2) behavioural economics studies on intertemporal and interpersonal choice. Sen's idea on the need to differentiate social rate of discount allowed to pave the way further followed by behavioural economists who do research on both (i) time (also known as delay or temporal) discounting and (ii) social discounting. Canonical works of Sen, Marglin, Tullock and Baumol on social rate of discount and newer (even recent) behavioural economics literature on choices made within time and social distance horizon strongly complement each other. As shown, the works of Sen considerably broadened the standard approach (discounted utility model) to the intergenerational choice as well as significantly affected economic debate in that area for years to come. Brief presentation of the discounted utility model and its implications is a first research task of this paper. The concise elaboration of research findings of (a) Sen and (b) behavioural economists comprises two remaining research tasks of this paper.

JEL Classification: D6, D9, I3, Q01

Keywords: social rate of discount, intergenerational choice, Amartya K. Sen, behavioural economics.

Introduction

Since *the issue of preserving the natural capital and the equitable sharing of it for current and future generations is a matter of global concern* (Sankar, 2011, p. 4), governments worldwide are looking for a proper, sustainable management approach to the commons (cf., e.g. the recent Paris Agreement that sets out a global action plan aiming at avoiding dangerous climate change). It should be however noted that reaching intergenerational equity demands first establishing a compromise of how we measure and compare welfare of our and future generations. Simply put, all intergenerational equity decisions can be traced back to the choice of social rate of discount (SRD).

The social rate of discount has been defined as the rate at which the society is willing to postpone current consumption for more consumption in the (near or even far) future (Marglin, 1963; Sen, 1967). The choice of SRD is a challenging task because it involves, among others, an assessment of *future* benefits to be received by *other* people. Observe that a choice of SRD concerns two dimensions: (i) the temporal dimension (future benefits) and

(ii) the social distance dimension (benefits for others). Therefore, the economic discussion related to the social rate of discount involves two types of discounting: (i) time (also known as delay or temporal) discounting (see, e.g. Frederick *et al.*, 2002) and (ii) social discounting (see, e.g. Jones and Rachlin, 2006).

In the case of time discounting, decision makers value rewards available at various moments in time (choices are made within a time horizon, hence the choice is *intertemporal*). As regards social discounting, the choices made concern rewards to people occupying various positions along the axis of social distance (choices are made within a social distance horizon, hence the choice is *interpersonal*). Persons are distributed along the social distance axis according to the criterion of diminishing proximity to the decision maker. The decision maker occupies position no. 1, then there is the person closest to her (in this text decision makers are in the feminine), whereas further along the axis there are people known to the decision maker only by sight, and further on – strangers.

Observe that the intergenerational choice is entangled both in intertemporal and interpersonal considerations. Obviously, this makes the choice being discussed particularly complex and perplexing.

The aim of this paper is to, at least to some extent, disentangle the complexity of the intergenerational problem by presenting important voices in the economic discussion on the social rate of discount. This survey paper puts special emphasis on the contributions made by Amartya K. Sen (section 2) in the development of theory of social rate of discount. As shown in further sections, the works of Sen (1961, 1967, 1982) considerably broadened the standard approach (*discounted utility model*, see section 1) to the topic as well as significantly affected economic discussion in that area for years to come. Brief presentation of the discounted utility model and its implications is a first research task of this paper. Sen's research paved the way that was later followed by behavioural economists studying (both individual and national) differences in rates of discount as well as social conditions underlying the SRD selection process (section 3). The concise elaboration of research findings of (i) Sen and (ii) behavioural economists comprises two remaining research tasks of this paper.

The highly complex SRD-related issues can be organised by using the fundamental descriptive dimensions of economic agent (cf. *Figure 1*). The basic dimensions distinguished in the economic concept of man are (Hendrikse, 2003): decision maker's *degree of rationality*, *behavioural orientation* and *willpower*. In neoclassical economics humans are believed to be fully rational (degree of rationality axis, cf. figure 1) and perfectly selfish (behavioural orientation axis). Full rationality means that the ratio of decision maker's cognitive capacities to problem complexity always equals 1 (Hendrikse, 2003). Consequently, a decision maker is able to immediately solve any problem and makes no mistakes. Bounded rationality occurs when the ratio of decision maker's cognitive capacities to problem complexity is lower than 1 (Simon, 1961). Procedural rationality occurs when the ratio of decision maker's cognitive capacities to problem complexity is nearly zero (Hendrikse, 2003). In such case, the decision-making environment becomes too complex, hence the agent resorts to rigid, external procedures. Perfect selfishness should be in turn interpreted in the following way: a man is always guided by self-interest (attempts to maximise own benefits, whilst minimising costs) and always complies with obligations (does not lie or cheat; Hendrikse, 2003). The third attribute of a decision maker, as seen in neoclassical economics, is unbounded willpower. This means that humans boast full (complete) self-control in the temporal dimension. What follows from this assumption is attributing to a decision maker a fixed rate of time (also delay or temporal) discounting (this means that for an agent, the difference in value between today and tomorrow is proportional to the difference in value between a year from now and a year plus one day from now). The discount function used to model such (for a fixed rate of time discounting) intertemporal behaviour is then an exponential function (Graczyk, 2009).

The issues related to social rate of discount mostly pertain to two dimensions inherent in the economic concept of man, i.e. behavioural orientation and willpower. As it has been mentioned, a choice of SRD involves, among others, an assessment of *future* benefits to be received by *other* people. An assessment of decision maker's (time, delay or temporal) discounting rate of *future benefits* can be used to measure her willpower (degree of self-control). On the other hand, the (social) discounting rate of future benefits *gained by others* is useful to assess the decision maker's behavioural orientation (higher social discounting rates are characteristic of more selfish people).

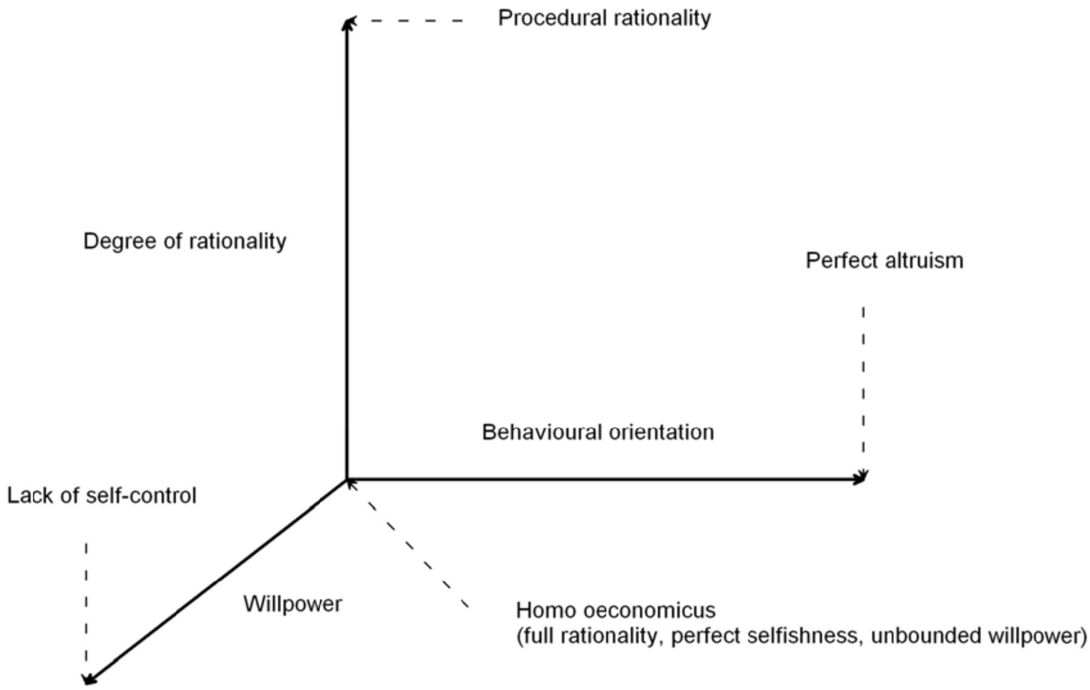

Figure 1. The economic concept of man: fundamental dimensions
Source: Own material based on Hendrikse (2003).

The topic of intergenerational choice and discounting has been debated in economics for many years and by many researchers (the topic can be at least traced back to seminal works of Cambridge scholars – Pigou and Ramsey, see, e.g. Ramsey, 1928). Therefore fully-fledged presentation of all important arguments in the topic is not possible to achieve in such a brief paper. This seems however a natural limitation of a review article. Sources of references are journal articles and books.

1. Discounted Utility Model

As already mentioned, the topic of discounting has been debated for many years in at least the following research fields: (1) development economics and the theory of economic growth (Sen, 1961, 1967, 1982; Marglin, 1963; Tullock, 1964; Lind, 1964; Harberger, 1969; Dasgupta *et al.*, 1972; Sjaastad and Wisecarver, 1977; Lind, 1982; Edwards, 1985; Newbery, 1990; Warr and Wright, 1990; Arrow *et al.*, 2004), (2) environmental and natural resource economics (Philibert, 1999; Pearce *et al.*, 2003; Hepburn *et al.*, 2009) and (3) behavioural economics (Jones and Rachlin, 2006, 2009; Rachlin and Jones, 2008; Ostaszewski and Osiński, 2011; Osiński *et al.*, 2015).

The standard economic model underlying scientific discussion in the first and second of the aforementioned research fields is the discounted utility model (see, e.g. Gowdy *et al.*, 2013). In behavioural economics, this model is usually treated as a point of departure and, further, as an object of scientific critique in studies focused on the intergenerational choice (Frederick *et al.*, 2002).

Discounted utility refers to the discounted value which results for the decision maker from consumption of goods over time (Gowdy *et al.*, 2013). Such interpretation of discounted utility can be found in the canonical works of Cambridge scholars (Pigou and Ramsey, cf., e.g. Ramsey, 1928) as well as Paul Samuelson (1937). Within the framework of the discounted utility model, the decision makers' obligations towards future generations boil down to choosing the optimal value of social rate of discount (see, e.g. Dasgupta and Heal, 1974). In the discounted utility model decision makers should strive to maximise the total value of current and future (discounted) social welfare. The value of future welfare is usually discounted with a fixed rate, the value of which reflects, among others, degree of society's patience, i.e. the degree of preference for short-term benefits with the simultaneous delay in the corresponding costs (Gowdy *et al.*, 2013).

The optimisation problem (continuous and for a single consumption good) in the discounted utility model refers to maximising the value of social welfare as a function of time (cf., e.g. Albrecht and Weber, 1995; Gowdy *et al.*, 2013):

$$W(t) = \int U[C(t)]\left[\frac{1}{(1+r)^t}\right]dt \qquad 1.$$

$W(t)$ denotes social welfare as a function of time (t), U denotes immediate utility resulting from consumption (C) of a given good, while $\frac{1}{(1+r)^t}$ is the discount factor (for the discount rate r). In the standard approach (Ramsey, 1928; Cass, 1965; Koopmans, 1965; see also Gowdy *et al.*, 2013), discount rate r is the sum of pure rate of time preference (ρ) and the product of the degree of curvature of the utility function (this degree defined as: $\theta = \frac{u^{"}(c)c}{u^{'}(c)}$) and the expected rate of economic growth (g):

$$r = \rho + \theta g \qquad 2.$$

The pure rate of time preference is a measure of how much more desirable is consuming a good now than consuming it in the future.

Equation 2 raises a few questions. First, with such a formulation of discount rate, an assumption is made that the whole economy is a single decision maker (Gowdy *et al.*, 2013). Observe that formula 2 considers just one value of the rate of time preference characteristic of an economy, which means that the economy is perceived as a single decision maker. Second, determining ρ value is a problematic task[1]. According to Ramsey (1928), the rate of time

[1] Works of Cole (2008), Quiggin (2008), Stern (2007) and Gowdy and others (2010) address in great detail the worldwide discussion on the choice of the social rate of discount. The cited authors underline that there are no purely economic justifications for the selection of a specific value of social discount rate (proposed justifications often involve ethical and political judgments, as well as opinions based on natural sciences – ecology or medicine).

preference should be equal zero (Ramsey would refer to any other choice of the rate of time preference as "telescopic myopia"). However, empirical studies show that decision makers tend to select various rates of discount depending on their income levels (Hausman, 1979), consumption good characteristics (Train, 1985), own intelligence (Osiński *et al.*, 2014) or the adopted cognitive perspective (Gowdy *et al.*, 2013).

The choice of proper rate of discount seems even more difficult in the case of long-term (and long-lasting) environmental concerns – loss of biodiversity and climate change (Carson and Roth Tran, 2009; Gowdy, 1997; Gowdy *et al.*, 2013). If the usually suggested (cf., Philibert, 1998) values of discount rate (5% – 10%) are applied in the cost-benefit analyses, the results of such studies will attribute a negligible current cost to a likely future environmental crisis (Philibert, 1998). As a result, limiting consumption today seems groundless. On the other hand, if sufficiently low (substantially lower than usually suggested) values of discount rate are applied, the results will suggest a considerable need to limit current consumption (which means saving much more for the sake of future, possibly better-off generations, see Philibert, 1998). And so, both solutions seem flawed.

What is worse, long-term environmental concerns are affected by the so-called *isolation paradox*. The isolation paradox (Sen, 1967) is a straight-forward extension of the *prisoner's dilemma* (isolation paradox is a N-players game, whilst the prisoner's dilemma is a 2-players game, for details, see section 2). As far as climate change is concerned, isolation paradox can be characterised as follows (Philibert, 1998). Decision makers perceiving climate change as a threat may wish to protect future generations, e.g. through reducing consumption now. However, decision makers tend to believe that an individual effort would make a very limited impact on climate change (Philibert, 1998). For instance, in the context of international climate negotiations, it is believed that none of the participating states has a great enough share in global greenhouse gas emission to hope for a direct return through reducing it (Philibert, 1998). Each of the states expects to avoid introducing reductions, whilst hoping that the remaining participants will, in fact, cut down their emissions. The incentive structure of this decision problem is conducive to achieving non-optimal results from the point of view of participating states perceived as a community.

The discounted utility model offers a precise and straight-forward description of the discounting problem. Fully rational decision makers select the optimal value of discount rate – ready for being used in calculations of discounted value of various social investments (Gruber, 2007; Gowdy *et al.*, 2013). However, the critics of the discounted utility model like to stress that introducing into the model positive value of rate of time preference is completely unjustified, as "well-being of certain people should not be valued lower just because those people live in a different time" (Gowdy *et al.*, 2013, S100; see also Ramsey, 1928; Philibert, 2006). As a result of adopting positive value of rate of time preference, social rates of discount may be consistently overestimated. In the view of many critics of the discounted utility model (see, e.g. Gowdy *et al.*, 2013), it is also erroneous to assume that due to a positive wealth effect (resulting from economic growth), future generations will be better off than current ones. Philibert (2006) argues that future generations may have to cover considerably higher environmental costs than current ones. Moreover, the future beneficiaries of today's social investments undertaken by investors from developed countries may be residents of developing countries. Finally, one should be aware of the fact that numerous empirical studies point to the difficulty encountered by decision makers in retaining self-control in the temporal horizon (see, e.g. Rachlin and Jones, 2008; Zielonka *et al.*, 2009; Osiński and Karbowski, 2015). This means that decision makers in their valuations prioritise excessively the importance of near future, depreciating more distant events (hence, hyperbolic discounting occurs). As a result, attributing to decision makers just one value of social rate of discount seems groundless. In the technical sense, valuations made by decision makers who attach excessive importance to the near future can be modelled by hyperbolic discount function (Graczyk, 2009). The hyperbolic model is characterised by a high fit to empirical data (see, e.g. Loewenstein and Prelec, 1992; Osiński and Karbowski, 2015).

Because of the aforementioned reasons, the values of social rate of discount applied in the discounted utility model may be very dissimilar to the actual valuations made by members of a given society.

2. Sen's Contribution

The choice of SRD is a challenging task because it involves, among others, an assessment of future benefits to be received by other people. One should notice that economic discussion on the social rate of discount is heavily entangled in the problem of social interdependence, which makes the process of selecting the proper value of social rate of discount even more controversial. The explanation of the aforementioned issue of social interdependence can be found in the seminal works of Amartya K. Sen (1961, 1967). This topic is covered in detail in the next subheading.

2.1. Isolation Paradox and Assurance Problem

Sen (1967) distinguishes two, often confused, cases of social interdependence (see also Sen, 1961; Marglin, 1963; Tullock, 1964; Baumol, 1952) discussed in literature on the social rate of discount, i.e. isolation paradox and *assurance problem*.

Sen (1967) defines the isolation paradox as a N-players game in which each of the players has to choose one of the two available strategies that can be conventionally named "cooperative strategy" and "competitive strategy". The structure of payoffs is such that (1) each of the players will be better off if she selects the competitive strategy over cooperative one (regardless of choices made by other players), and (2) each player will be better off if cooperative strategy is selected by all players than when all of them select the competitive strategy. Consequently, the result in which competition is selected by all players is not Pareto-optimal and cooperative strategy remains strictly dominated. For N=2 the isolation paradox is simply the prisoner's dilemma.

The following *figure* allows to illustrate the strategic choice in prisoner's dilemma.

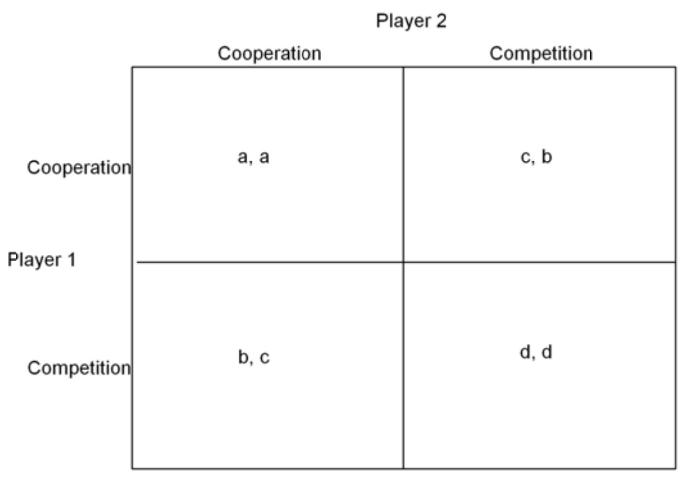

Figure 1. Prisoner's dilemma
Source: Own material.

The payoffs are represented in the *figure* by subsequent Latin alphabet letters. The following inequality holds for the prisoner's dilemma to be valid: $b > a > d > c$ (and $a > (c + b)/2$ for the iterative version).

When both players cooperate, both of them receive payoffs amounting to *a*. When player 1 decides to cooperate and player 2 to compete, the payoff of player 1 amounts to *c* (which is the lowest in the game), while the payoff of player 2 is equal *b* (the highest in the game). The payoffs are symmetrical when player 1 competes, an player 2 cooperates. Under such circumstances the payoff of player 1 is *b*, and of player 2 – *c*. If both players decide to compete, both of them receive payoffs amounting to *d*.

Such structure of payoffs produces strong individual incentives to compete. Therefore, rational and selfish players should decide to compete to maximise their private benefits. The set of strategies (Competition, Competition) is the only Nash equilibrium in pure strategies of this game.

An interesting point to notice here is the conflict between players' private and social interests. If the players behave in rational and selfish manner (both compete), their resultant payoffs will in fact be lower than in the case of mutual cooperation. What is then desirable in the prisoner's dilemma for an individual is undesirable for players treated as a community.

A game similar to the isolation paradox is the one that Sen (1967) refers to as the assurance problem. The condition (2) of the isolation paradox is the same for the assurance problem. What is different is condition (1). Under special circumstances of the assurance problem, when all players except for player i select cooperative strategies, also the i-th player prefers it. In all other cases, i-th player prefers the competitive strategy. For N=2 the assurance problem is simply the *assurance game*.

The assurance game is considerably more cooperative in nature than the prisoner's dilemma. The following inequality holds for the assurance game to be valid: $a > b > c$ (see *Figure 2*). Please note that unlike the prisoner's dilemma, in the assurance game two Nash equilibria in pure strategies (consisting of mutual cooperation (Pareto optimal) or mutual competition) can be found. Confer that in prisoner's dilemma, the only Nash equilibrium in pure strategies is mutual competition and, what is more, competitive strategy itself is considered to be the dominant strategy (competition leads to higher payoffs, regardless of other decision maker's choices). In assurance game there is no dominant strategy. Competition is preferred when the other player selects the competitive strategy. On the other hand, when the other player opts for cooperation, it becomes the preferred option.

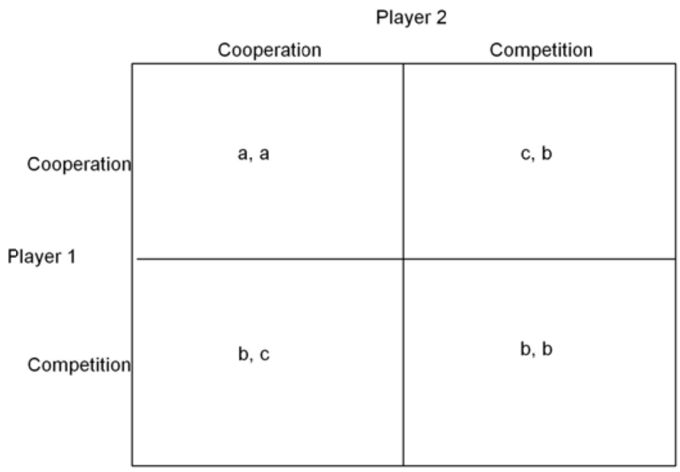

Figure 2. Assurance game
Source: Own material.

By referring to Grzelak's theory of social value orientation (2009), various games may be classified along the "competition – cooperation" axis (from the least to most cooperative games). The games discussed by Sen (1967) can be then classified in the following way (see *Figure 3*).

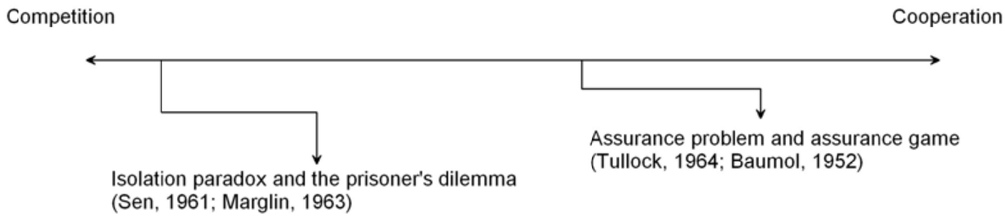

Figure 3. Isolation paradox and the assurance problem in the light of social value orientation theory
Source: Own material.

In 1952 William Baumol elaborated upon the intergenerational choice as follows: neither private interest nor altruism (*except if (s)he has grounds for* ***assurance*** *that others, too, will act in a manner designed to promote the future welfare of the community*; Philibert, 1998, 2, bold font added) can compel a rational decision maker to invest to the benefit of future generations, and particularly of generations living in the far distant future, to a degree that is appropriate from the point of view of the society as a whole (Philibert, 1998). One should notice that such formulation of the intergenerational choice is closer to the assurance problem than the isolation paradox. A similar approach can be found in the work of Tullock (1964, p. 331) in which the intergenerational problem is seen as *interdependence of transfers from various benefactors in case of which a decision maker would be willing to offer something to another member of the society if she knew other people would do it even if she did not offer anything*. The reservation "if she knew" made by Tullock indicates that he considered the intergenerational choice to be the case of assurance problem.

In contrast, for Sen (1961, 1967) and Marglin (1963) intergenerational choice should be modelled rather by the isolation paradox than the assurance problem. And so, in Sen's work (1967, p. 115) we read: *in our case an individual will not do the saving even if (s)he knew that others were doing so*.

Sen exemplifies his reasoning in the work from 1961 (see also Philibert, 1998). The remainder of this section covers that example. A decision maker must then choose between a consumption unit now and three consumption units in 20 years. However, a decision maker knows that she will be dead in 20 years. While the decision maker cares about a prosperous life of future generations, certainly she does not care enough about it to sacrifice a unit of her current consumption for three consumption units for a generation living 20 years later. For this reason, she will prefer to consume that unit today. Then another person (say person x) comes along and informs the decision maker that if she saves that unit, person x will do the same (save a respective unit). If the decision maker changes her mind and opts for saving a given unit, the benefits of the future generation might be much greater than those considered thus far (possible benefits of future generation resulting from another person's offer amount to 6 consumption units in 20 years for saving one unit today).

Observe that the decision will at the end depend on the social rate of discount that the decision maker applies. Observe further that in fact we are discussing here two social rates of discount – (1) one makes it possible to determine a subjective value of a consumption unit for the decision maker if that unit is consumed by another person living now, (2) the other facilitates determining a subjective value of a consumption unit for a decision maker if that unit is consumed by a representative of the following generation. For instance, a decision maker may evaluate each consumption unit of the following generation to be worth 0.3 of the current consumption unit; moreover, she may evaluate each consumption unit of other members of the society to be worth 0.7 of the consumption unit for herself. For these numerical values, the decision maker will evaluate the social benefits of saving a consumption unit to be worth 1.8 of current consumption unit (6 times 0.3), and social costs – 1.7 (she gives up on the current consumption unit + other person does the same for a unit worth 0.7 of the decision maker's consumption unit). However, it should be borne in mind that if a decision maker acts in *isolation* (hence, she does not take into account other person's offer), social benefits would be equal 0.9 (3 times 0.3 of the current consumption unit), with social costs being equal 1 (as a result of abandoning own consumption).

According to Sen (1967) and Marglin (1963) the latter is the result to be expected in the context of intergenerational choice. The reasons for that as follows. First of all, offers made by others (like in the example above) are rare. Secondly, such offers often remain unexecuted (e.g. due to lack of proper enforcement mechanism). Finally, one should bear in mind that in the example above the decision maker obtains the best result when she consumes today the unit herself, while others commit themselves to saving.

Consequently, in the view of Sen (1961, 1967) and Marglin (1963), the pertinent model of intergenerational choice is the isolation paradox and not the assurance problem.

3. Findings of Behavioural Economics

In the previous sections (i) the discounted utility model (as a standard tool used by economists to study intergenerational choice) as well as (ii) Sen's concepts that further explore the issues of social rate of discount were discussed. Unlike the case of discounted utility model (as it has been already mentioned, the discounted utility model considers just one and fixed rate of discount; moreover, that model is aggregative in nature and do not allow for social interdependence in the economy), Sen's concept allows differentiated rates of discount (e.g. decision makers may differ in terms of discounting rates over time and across social distance, what is more, decision makers select various values of discount rate for the consumption by current and future generations). Sen also embeds the process of discount rate selection in a social context (social interdependence considerations).

Sen's view of intergenerational choice seems more realistic than the standard approach, though undoubtedly makes the economic theory of intergenerational choice less mathematically tractable (Gowdy, 2004). Sen (1961, 1967), not being himself a behavioural economist, paved the way followed by other scholars (later known as behavioural economists) who studied both intertemporal (research on time discounting, cf., e.g. Thaler, 1981; Kirby and Herrnstein, 1995; Laibson, 1997; Frederick *et al.*, 2002) and interpersonal choice (research on social discounting, cf., e.g. Jones and Rachlin, 2006, 2009; Rachlin and Jones, 2008; Ostaszewski and Osiński, 2011; Gowdy *et al.*, 2013; Osiński *et al.*, 2015).

Numerous empirical studies in the field of behavioural economics point to the interpersonal differentiation of discount rates (Urminsky and Zauberman, 2015; Delton and Robertson, 2015). Large sample studies (Reimers *et al.*, 2009, N=42,863; Warner and Pleeter, 2001, N=55,000) have shown that discounting rates are much higher in the case of younger, less educated and lower earning people. Shamosh and Gray (2007) observed that people with a lower IQ level exhibit higher temporal discounting rates (what means that such people seem less patient). Persons exhibiting lower temporal discounting rates tend to achieve better grades (Kirby *et al.*, 2005; Lee *et al.*, 2012) as well as better results in standardised school tests (Benjamin et al., 2013). The differences in temporal discounting have also been noticed between societies living in different states and nationalities (Poulos and Whittington, 2000; Castillo *et al.*, 2011).

Empirical (mostly experimental) research has also demonstrated variability of temporal discounting rates for an individual decision maker (see, e.g. Loewenstein and Prelec, 1992; Laibson, 1997). The discounting rate over time can be measured by determining one's preferences in choices between (usually monetary) rewards – (i) a smaller, sooner and (ii) a larger, more delayed (Urminsky and Zauberman, 2015). A delay in receiving any of the rewards by the same amount of time strengthens one's self-control, namely the choice of a larger reward that would be received later (Rachlin and Green, 1972; Hyten *et al.*, 1994; Osiński and Karbowski, 2015). For instance, in the case of an alternative "PLN 50 today or PLN 100 tomorrow" in comparison to an alternative "PLN 50 in a year or PLN 100 in a year plus one day", the probability of selecting PLN 100 is higher in the latter proposal. What is more, a decision maker may simultaneously opt for "PLN 50 today" against "PLN 100 tomorrow" and "PLN 100 in a year plus one day" against "PLN 50 in a year". This phenomenon, being an example of decision maker's preference inconsistency, has been named in literature (see, e.g. Osiński i Karbowski, 2015) a *preference reversal*. The reason behind a preference reversal is the fact that for the same decision maker the values of temporal discounting rate are higher in the case of short delays (periods closer to present day) than the long ones. In the technical sense, such intertemporal valuations can be modelled by the hyperbolic discounting function (Laibson, 1997; Gowdy *et al.*, 2013).

Empirical studies have also pointed to differentiation in social discounting rates (Delton and Robertson, 2015). Persons with lower social discounting rates are more likely to choose cooperative strategy in games based on conflict of private and social interest (prisoner's dilemma, public goods game, see, e.g. Jones and Rachlin, 2009; Safin *et al.*, 2013; Locey *et al.*, 2013). The social discounting rate is also negatively correlated with decision maker's fluid intelligence (Osiński *et al.*, 2014) and agreeableness (Osiński, 2009; Kirkpatrick *et al.*, 2015), whereas it is positively correlated with decision maker's level of neuroticism (Osiński, 2009).

Moreover, experimental research shows that in social discounting the preference reversal is also observable (Osiński *et al.*, 2015). In the quoted study the participants were asked to think of a list of 100 persons ranked according to the social distance (the first on the list is the person closest to the participant, while the last one is someone (s)he knows only by sight), and then the participants decided between a monetary reward for themselves and the reward for persons occupying specific positions on the list. Researchers expected that moving a pair of beneficiaries (occupying different positions along the social distance axis) by the same distance will enhance the relative attractiveness of the reward for the more distant people. This expectation can be illustrated with the following proposals: "PLN 50 for myself or PLN 100 for person no. 1 on the list" versus "PLN 50 for person no. 10 or PLN 100 for person no. 11". The likelihood of selecting PLN 100 should be higher in the case of the second proposal. The decision maker may simultaneously prefer "PLN 50 for myself" to "PLN 100 for person no. 1 on the list" and "PLN 100 for person no. 11" to "PLN 50 for person no. 10". Such results (indicating a preference reversal in social discounting) were in fact obtained by Osiński and others (2015). Clearly, in the technical sense, such social valuations can be modelled by the hyperbolic discounting function (cf. Rachlin and Jones, 2008; Osiński and Karbowski, 2015).

Sen's concept, apart from allowing for differentiated rates of discount, also "socialises" the process of discount rate selection by pointing at social controversies related to that selection and showing how entangled this selection is in strategic interdependence. Also the latter contribution was further developed in subsequent publications on the topic (see, e.g. Chichilnisky, 1996; Li and Löfgren, 2000; Pearce *et al.*, 2003).

Works of Chichilnisky (1996) and Li and Löfgren (2000) demonstrate that hyperbolic discounting may be a result of social contract under which the current generations in their actions must take into account future generations' well-being (see also Pearce *et al.*, 2003). This is to prevent dictatorship (sic!) of one generation over another (Pearce *et al.*, 2003).

Chichilnisky (1996) considers a scenario in which current decision makers use a mixed strategy: (1) maximisation of discounted value of net benefits and (2) the sustainability strategy emphasising future generations' well-being.

Li and Löfgren (2000) consider in turn a simplified scenario in which the society is composed of two persons only – the utilitarian and conservationist. Those persons individually decide on temporal allocation of available resources. Decision makers differ in terms of discount rate values towards the future utility of consumption: the utilitarian exhibits higher values of discount rate than the conservationist. In such a case, hyperbolic discounting may result from the two facts: (1) existence of different values of the social rate of discount in the society and (2) different weights ascribed to the utilitarian and the conservationist in the social decision-making process. If, due to political competition, the value of social rate of discount shifts towards the rate applied by the utilitarian, the discount function becomes hyperbolic in nature.

Clearly, all behavioural studies being discussed support Sen's concept that, first, allows differentiated rates of discount (e.g. decision makers may differ in terms of discounting rates over time and across social distance, what is more, decision makers select various values of discount rate for the consumption by current and future generations), and second, embeds the process of discount rate selection in a social context (social interdependence considerations). Using Lakatosian (1977) terms, we may then coin the hypothesis that Sen's concept of the social rate of discount turned out to be a progressive research program.

Conclusions

As regards economic discussion on the social rate of discount, Sen (1961, 1967, 1982) first focused on rigorous theoretical propositions of Cambridge scholars (works of Ramsey and Pigou from the early 1920s) and Paul Samuelson (1937), but then greatly extended their ideas.

From the later Sen's contributions to the topic the following (among others) can be deduced: (i) the need to differentiate social rate of discount (today, thanks to research in behavioural economics we know that decision makers really differ in terms of discounting rates over time and across the social distance, what is more, decision makers attach different values of discount rates to the consumption by current and future generations) and (ii) the importance of social context within which the value of discount rate is selected (cf. Sen's considerations to social interdependence).

At the end, it is worth noticing that Sen's ideas allowed to pave the way followed by other economic scholars (including behavioural economists) who continue the strand of research discussed in section 2 by working on both (i) intertemporal (Thaler, 1981; Kirby and Herrnstein, 1995; Laibson, 1997; Frederick *et al.*, 2002) and (ii) interpersonal choice (Jones and Rachlin, 2006, 2009; Rachlin and Jones, 2008; Ostaszewski and Osiński, 2011; Gowdy *et al.*, 2013; Osiński *et al.*, 2015).

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