A Two-step Decision Making Model

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Abstract. EDU framework has both ideological and empirical defects for it only considers one link of the whole decision-making process ignoring another link of selection of stage goal and 'strategic' plan, which plays an important role in the direction and affects the following allocation of specific resources. By investigating people's decision behavior, a two-step decision making model is developed on the basis of EDU framework and TRP theory to illustrate a decision-maker's thinking and behavior characteristics. Introduction of value function of three reference points and strategic plan make the process of choice more realistic than utility function and more crucial to explain the chosen results. In addition, self-control problem is incorporated into the model to relax the underlying assumption of plan's being fully implemented, which makes decision more implementable and effective.

Introduction

Since Samuleson (1937) proposed a discounted utility model of intertemporal decision making, followed by the expected utility theory by Von Neumann and Morgenstern in 20th Century 50's, the expected discounted utility (EDU) model combining the two theories has been used as a standard benchmark to analyze intertemporal decision making under risk[1]. There is no doubt that this paradigm has the advantages of parsimony, tractability, conceptual insightfulness, generalizability, meeting the requirements of a 'good' model(Gabaix and laibson,2008)[2]. However, this model simplifies some important mechanisms of decision making too much that its empirical consistency and predictive precision are not good.

From the point of ideas of modeling, EDU model may ignore two important mechanisms.

Firstly, the EDU model maximize the consumer's discounted utility by allocating consumption in each period with the constraints of income. Obviously, consumption and income is closely related. However, people can change the total utility by altering the way of earning income (income function). That is, income function can be endogenetic rather than exogenous in the system. Moreover, this change seems to be more effective to improve the total level of utility. In reality, people are constantly increasing total utility by changing income function along with the time. How to choose the more profitable way of earning income is not reflected in the EDU model.

Secondly, EDU model assumes that people believe the long-term optimal decision can be implemented effectively. That is, people's rationality can ensure adequate self-control, which is seen a limited psychological resource of self-constrains to temptation. In fact, many 'effective', 'far-sighted' decisions are not implemented well because each period self has incentives to deviate

from the initial decision, leading to the goal's failure. Adding the consideration of the decision's being strict enforcement without deviating is an important supplement to the standard benchmark.

From the point of empirical hypothesis of the model, there are two important aspects not conforming to the reality:

Firstly, although people would consider the subjective satisfaction degree of consumption in the process of decision-making, but recent psychological researches show that human being's subjective feel mainly come from the feeling of a certain activity's cost and avenue comparing to some kinds of reference points. As an empirical model, EDU model ignores the main substance of subjective feeling, leading to its lack of empirical consistency.

Secondly, the EDU model uses discount function representing decision-maker's preference time (by giving different weights to each period's utility). It assumes that a more recent utility level, relative to decision point of time, should be assigned a larger weight. In essence, the assumption is that the agent has the short-sighted(myopic) characteristics. Although a large number of experiments show that human and animals in many cases are short-sighted, there are still some experiments show that the time preference assumption does not always hold (Rubinstein, 2003; Kan Takeuchi, 2011)[3][4]. Loewenstein(1987) believed a more general framework should include both possibilities of 'short-sighted' and 'far-sighted' characteristic, illustrating the conditions under which the agent is myopic or foresight[5].

Two-step Decision-making Model

We points out the EDU model's defects above not meaning to deny the importance of its insights of the allocation of resources. We think the existing defects lies in the EDU model only considering one link of the whole decision-making process, i.e studying the resource allocation part of the decision. But in fact before the resources' allocation step, there is a link of selection of stage goals and 'strategic' plan, which plays a key role in the direction, affecting the following allocation of specific resources. Therefore, a complete inspection of both link can better illustrate the decision-maker's thinking and behavior characteristics, strengthening the model's power of explanation and prediction. Therefore, this paper proposes a two-step decision making model.

The First Step: The Selection of Strategic Plan

Although the decision maker always hopes to maximize the lifetime's utility, the utility of whole life is always realized by one-by-one stage target's achievement and accumulation. Every stage goal contains the decision-maker's belief of how to pursue the maximum utility of life. Therefore, the essence of setting right stage goal is consistent with the target of pursuit of whole life's utility. After determining the target, selection strategic plan is an important link to achieve the target. For example, as to poor families, the first stage goal is climbing out of poverty when it pursues the life's maximum utility, for climbing out of poverty precede further development. If it could not get rid of poverty, the lifetime utility can only experience in poverty. When getting rid of poverty is set as the goal, the family will consider in choosing a best strategic plan from feasible plans such as investing in education, investment in economic crops, taking on some business activities or migrating for work, with different 'cost', avenue, risk and length of time. We propose a value function framework based on the Tri-reference-point theory (referred to as TRP) to evaluate and select an optimal strategic plan.

The TRP theory is proposed by summarizing many psychology research on choices behavior of people by Wang and Johnson (2012)[6]. According to this theory, the subjective value of the

decision maker is the basis for decision-making, and representation of value function is the core of decision theory. A lot of human decision studies emphasize the reference point of 'status quo' has an important influence on value, which is prominent in prospect theory. However, many recent researches show that important reference points are more than 'status quo', and 'status quo' in many cases is not the most important. Wang and Johnson summarize three important reference points on the basis of previous studies and their characteristic, proposing the TRP theory. According to the theory, three kinds of reference point are confirmed by 5 selection criteria: status quo (referred to as SQ), goal(referred to as G) and minimum requirements (referred to as MR). The characteristics of the value function of the corresponding reference point are given. As shown in figure 1.
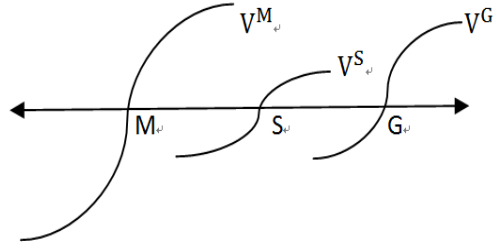

Fig. 1 reference point and value function

In figure 1, SQ reference point corresponds to the consumption level C_s,and G to C_G, MR to C_M.An extra two assumptions are made in the decision frame: firstly, the strategic plan's value is calculated at the initial and final states only, intermediate states not considered; secondly, decision maker by collecting relevant information acquires plan's costs and possible returns, and information searching cost is 0. Costs of the Lth strategic plan is initial spending(status quo's consumption level) decreased to C_L^1, and returns arrive at C_L^2 at the final consumption level. In order to simplify the model's form, assuming that there are two possible numerical value of C_L^2: a higher level (C_L^{2h}) and a lower level (C_L^{2l}), which corresponds to the possibility p^h and p^l. Decision-maker would choose the action plan whose weighted value is maximum according to the three reference value point and respective value function. The specific model is as follows:

$$Max\ H\left(C_L^1,C_L^2,C_s,C_M,C_G,\theta_M,\theta_G,\theta_S\right)$$

$$s.t.\ H = \sum_{K=M,G,S}\theta_K \cdot V^K\left(C_L^1,C_L^2,C_K\right)$$

$$\theta_M + \theta_G + \theta_S = 1\ and\ \theta_M > \theta_G > \theta_S$$

$$V^K\left(C_L^1,C_L^2,C_K\right)=v^K\left(C_L^1-C_K\right)+\delta^{\tau(L)}Ev^K\left(C_L^2-C_K\right)$$

$$Ev^K\left(C_L^2-C_K\right)=\sum_{i=h,l}p^i \cdot v^K\left(C_L^{2i}-C_K\right)$$

Wherein, H representing the total weighted value, $\theta_M,\theta_G,\theta_S$ representing respectively the weight of the three reference points, $V^K\left(C_L^1,C_L^2,C_K\right)$ representing the Lth action plan's value corresponding to the reference point K, v^K representing the value function of the reference point K, δ representing the time discount rate, $\tau(L)$ representing the Lth action plan's requiring length of time.

Through the above framework, decision makers can choose the optimal strategic plan according to the weighted value. Selection of strategic has two side effects: one is the implementation of the

plan and realization of stage goal may change the income function. For example, a family depending on investment in education to get rid of poverty may earn a big money from the second or the third industry instead of a low income of agriculture from the first industry, when human capital investment is completed. Another side effect is that it leads to the agent's time preference changing. We suppose that people as animal have the instinct of short-sighted time preference, which is tested and confirmed by many experiments. However, once given the target and a clear plan of action, the time preference would alter with agent's attention to the action's value and become foresight. The discount factor changes into Δ, and $\Delta = \delta \cdot H(L)/H(0)$。

The Second Step: Deciding the Optimal Resource Allocation Scheme

Next, decision-maker will decide the optimal resource allocation scheme according to the selected strategic plan. For example, when the poor made the choice of investment in education as the most 'valuable' scheme of poverty alleviation, the house would allocate resources in agricultural production, education investment, consumption to maximize the discount utility, with the premise of education investment ensured. However, compared with standard EDU model, this paper has two extensions.

The first extension is mentioned above, i.e. the time preference will be adjusted according to the value of optimal strategic plan versus present action value.

The second is, rational or bounded rational agents should consider the problem that the resource allocation plan may not be implemented effectively during the whole execution process. In fact, we can often observe that the goal is not reached because of an 'effective' plan's not being effectively implemented. One of the key reasons is that the agent, facing a temptation from real and immediate consumption instead of waiting, has the impulse of deviation from the original plan, which could increase current utility. When he cannot effectively control the impulse, he can increase current consumption despite of the original resource allocation scheme, so that the original plan was not effectively implemented. For example, for a poor family, to invest in child's education takes more than ten years requiring family members resisting a great deal of temptation of consumption, such as: the old man may not get the treatment of chronic disease, parents can not buy some nutritional food for adolescent brothers, families can not buy new clothes all the year round. If they don't invest in education they may increase the consumption expenditure to satisfy the current demand. Obviously, deviation from the plan of investment in education is attractive in the current period, there is impulse of deviation in the execution period. We think that rational decision-maker at the decision point needs to anticipate this problem and solve it in the decision-making framework. We add constraint condition in the model to control the possible impulsive behavior. Specific model is as follows:

$$\underset{C_t}{Max} \, E\left[\sum_{t=1}^{T} \left(\Delta^t \cdot u(C_t) \right) \right]$$

$$s.t. \quad C_1 \geq C_N^1 ; C_T \geq C_N^{2CE}$$

$$\Delta = \delta \cdot H(N)/H(0)$$

$$y_t = f_N\left(s_{t-1} \cdot y_{t-1} \right)$$

$$y_0 = \overline{y}$$

$$W\left(T\left(s_t, C_t - C_G \right) \right) \leq \overline{W} + \beta \cdot t$$

The objective function is to maximize the expected total utility in the total period of T(T denotes the length of time of the selected optimal strategic plan, assuming the Nth strategic plan is optimal). The total utility is the sum of every period utility discounted by factors to the decision point. The first constraint condition means that the initial consumption level of resource allocation must be higher than the Nth strategic scheme initial consumption level; moreover, the final consumption level must also be higher than the Nth strategic scheme final consumption certainty equivalent level(C_N^{2CE})denotes certainty equivalent of weighted value of final possible consumption). The two conditions together mean the Nth strategic scheme's realization. The second constraint condition means that the discount factor is changed according to the value of the Nth strategic plan. $H(0)$ denotes the value of the status quo's plan. Obviously, the value of the Nth strategic plan chosen in the first step satisfies the condition $H(N) \geq H(0)$, therefore $\Delta \geq \delta$, reflecting the decreased short-sighted tendency. The third constraint condition reflects the income function. The fourth constraint indicates the initial resources endowment of $\bar{y}$. The fifth constraint means in every period although the subject has the impulse of deviation from the optimal plan, by virtue of will power, agent can effectively control his behavior of resisting temptation. The initial willpower level is $\bar{W}$, and with the exercise of willpower it will improve at the rate of β in each period (Muraven and Baumeister, 2000; Inzlicht and Schmeichel, 2012)[7][8]. When the possible allocation of resources lead to temptation so bigger that the requiring willpower is exhausted and self constrain is out of control, changing the allocation plan of resources, reducing the temptation to guarantee the implement of plan is necessary. Of course, the decision-maker can make a commitment or levy an extra cost on the executor to ensure the implement of scheme. In a word, decision-making framework should take into consideration of the implementation issues. Specific control methods can be incorporated into the model framework in different ways.

This two-step decision framework is the result of authors' research of the poor's decision-making activity, but we believe that it can be applied to study the broader economic behavior. It not only has some good characteristics of a good model's requirement, it also provides some insights into the ways of endogenous preference. So far, this model is constructed based on psychological theory and experience and observation of the poor's activity, we hope the model be tested and modified through more economic experience in future.

Summary

EDU framework has both idea and empirical defects because it only considers one aspect of decision-making ignoring the selection link of stage goals and 'strategic' plan, which plays a role in the direction, affecting the following allocation of specific resources. This research proposes a two-step decision making model, inspecting both link of decision process to understand decision-maker's thinking and behavior characteristics better. Firstly, introduction of value function of three reference points make the choice of strategic plan more realistic than utility function. Secondly, the model provides some insights into the ways of endogenous time preference and avenue function, which makes the parameter's value has definite sense without random. Thirdly, the model takes into consideration of the self-control and implementation problems, which would change the idea of allocating resources deeply and make decision more implementable and effective.

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