Individual and Household Saving Decisions: Theoretical Models and Experimental Evidence

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1 Introduction

Deciding how much money to save is a fundamental problem that people face throughout their lives. The average adult repeatedly earns an income that must be allocated between necessities, leisure, investments, and saving. One common example is deciding between spending disposable income on a fancy dinner or saving it in a retirement account. Despite the importance and prevalence of saving decisions in daily life, people seem to struggle to save efficiently. Between 2019 and May 2020, 15 percent of adults in the United States reported that they would finance a $400 expense with their credit card and subsequently carry a balance, which is analogous to taking out a loan. Similarly, 12 percent of adults reported that they would not be able to afford a $400 expense if it occurred at that time (Federal Reserve, 2020). This suggests that a significant population of adults in the United States does not have sufficient savings for emergencies. Furthermore, 25 percent of adults in the U.S. reported that they do not have any money saved for retirement (Federal Reserve, 2020), which suggests that people struggle to make both short-term and long-term saving decisions.

To better understand how people make saving decisions, it is necessary to examine the choices people face as both individuals and members of a household. In 2018, there were more than two million marriages in the United States (CDC, 2018). Saving behavior cannot be properly examined without considering factors that affect people in each of these environments. Both decision and game theoretic approaches can provide insight into how people make saving decisions and real behavior can be observed through experimental data.

2 Individual Saving Decisions

2.1 General Model

A simple framework with which to model individual saving decisions is a repeated decision-making event in which one agent receives a stochastic income. The agent must decide what percentage of their current wealth to save for the future and what percent to spend on consumption. The total amount of money saved each period carries over to the next and there are a finite number of periods. There can be a variety of saving and consumption vehicles with different rules, such as a retirement account that cannot be withdrawn from until a specific period or decreasing marginal utility to consumption. This general model can be seen in laboratory experiments and optimal saving patterns can be solved for using dynamic programs or genetic algorithms. Depending on the specific case, this framework can be adapted to include insurance spending (Tracy et al., 2020) and randomly arriving income downturns and windfalls (Del Ponte & DeScioli, 2019).

This framework can be modeled as a two-period environment in which an individual has a pair of Von Neumann-Morgenstern utility functions which depend exclusively on wealth and one non-monetary parameter, such as current health or career satisfaction (Baiardi et al., 2014). It is important that the utility functions differ between periods because returns on consumption expenditure might change with age. An individual in this environment will seek to maximize their total utility between both periods and will face the following optimization problem (Baiardi et al., 2014):

$$u_1(w_1 - s, x_1) + u_2(w_2 + s(1 + r), x_2)$$

where u_1 is utility gained in the first period, w_1 is the individual's income in the first period, s is the amount of money saved, r is the interest rate, and x_1 is the amount of money spent on consumption in the first period. An individual seeks to maximize the above expression by deciding how much to save in the first period. Previous research has shown that there are four factors that influence the optimal ratio of consumption to saving: the number of descendants an individual has, the personal discount rate, the dependence of an individual's utility function on consumption, and the rate of return on saved money (Dasgupta, 2009). The only parameter that does not appear in the model above is the number of descendants, which might be added in the following way:

$$u_1(w_1 - s, x_1, d_1) + u_2(w_2 + s(1 + r), x_2, d_2)$$

where d_1 is spending on consumption for the individual's descendants in the first period. In this adaptation, utility is a function of wealth, individual consumption, and descendant consumption.

2.2 Uncertainty

There are a variety of uncertainties that an individual might face when making saving decisions: their job or primary source of income might be unstable, they might expect a probabilistic health event, their house might need unexpected repairs, etc. The two-period environment defined in the previous section can be extended to include uncertainties in the parameters of the utility function. Future income might be uncertain because an individual might get promoted or demoted at work. In this case, income can be expressed as a random variable (Baiardi et al., 2014):

$$\widetilde{w_2} = w_2 + \epsilon$$

where $\mathrm{E}(\widetilde{w_2}) = w_2$ and $\mathrm{E}(\epsilon) = 0$. The optimization problem faced by an individual in this environment can be rewritten with expected utility (Baiardi et al., 2014):

$$u_1(w_1 - s, x_1) + E[u_2(\widetilde{w_2} + s(1 + r), x_2)]$$

which can be similarly rewritten to include uncertainty on the interest rate and consumption. Perhaps the saved money is deposited into a volatile investment vehicle or the consumption variable represents medical expenses that cannot guarantee a specific outcome. Income in the first period cannot be uncertain because saving decisions are only made after the true value of income is realized. This uncertainty significantly changes the optimization problem and therefore the decision-making process that an individual faces. In an environment without uncertainty, there is no doubt about how much saved money will be worth in the second period, or how much utility one will gain from spending money on leisure or health expenses. In an environment with uncertainty, however, an individual now faces lotteries over outcomes with unknown probabilities associated with each outcome (Maschler et al., 2013). If money is saved in an investment vehicle, there is some probability that the market will crash in the second period; saving money for retirement is now a lottery. If money is spent on medical surgery, then there is some probability it is unsuccessful and there is no return on the expense; paying for surgery is now a lottery. This framework highlights the perspective that saving decisions reflect a choice between different types and levels of uncertainty.

2.2.1 Expanding the Framework

There are additional considerations that might be added to this two-period environment. The amount of money that an individual can save and withdraw in each period might be limited, such as in the case of a Roth IRA. In this case, the optimization problem becomes:

$$u_1(w_1 - \min[s, s^*], x_1) + E[u_2(\widetilde{w_2} + \min[\min[s, s^*], s^{**}](1 + r), x_2)]$$

where s is the amount of money that an individual wants to save in a regulated investment vehicle, and s^* and s^{**} are the maximum contribution and withdrawal amounts in one period, respectively. There might also be some probability of receiving a significant shock (Del Ponte & DeScioli, 2019; Tracy et al., 2020) in the second period, such as a medical emergency or lawsuit. The optimization problem in this two-period framework can reflect this as well:

$$u_1(w_1 - s, x_1) + E[u_2(w_2 + s(1 + r) - \widetilde{\gamma}, x_2)]$$

where $\widetilde{\gamma}$ is a random variable that represents the amount of money needed to pay for an income or health shock.

2.2.2 Precautionary Saving

Deciding how much to save in the presence of uncertainty is a common dilemma faced by individuals in their daily life. It might be the case that people save because of uncertainty in their future income and decide to put aside money to prepare for a probabilistic downturn. This change in saving behavior is a result of uncertainty about the future having a direct effect on time preferences (Fisher 1930, as cited in Menezes & Auten, 1978). Similar to the two-period framework and uncertainty introduced through random variables in the previous section, future income risk can be expressed as a lottery over outcomes in the following way (Menezes & Auten, 1978):

$$EU = \frac{1}{2}[u(C_1, C_2 + h) + u(C_1, C_2 - h)]$$

where h represents the size of a gamble that will increase or decrease income in the second period with equal probability and C_1 represents income in the first period. The expected utility of income between the two periods is simply $u(C_1, C_2)$. The risk associated with income in the second period changes the marginal rate of time preferences by twisting the indifferences curves over uncertainty such that the rate of time preference is lower under certainty than it is under uncertainty (Menezes & Auten, 1978). This reinforces the perspective that individuals constantly face lotteries over outcomes from one period to the next. Saving decisions are made in the face of many different risks and uncertainties which likely vary between individuals. For any individual, the income risk expressed above might be rewritten more generally as:

$$EU = p_i \times u(C_i^1, C_i^2 + h_i^a) + (1 - p_i) \times u(C_i^1, C_i^2 - h_i^b)$$

A similar generalization can be made to the optimization problem presented in the previous section.

2.2.3 Experimental Evidence

Experimental economics offers a unique testbed environment with which to better understand how individuals make saving decisions given different uncertainties and institutions. Previous research has shown that when faced with an uncertain stream of income windfalls and downturns, people save too little after experiencing a windfall but save too much after a downturn (Del Ponte & DeScioli, 2019). This suggests the amount of money that people save in a given period is dependent on their income in this period beyond the logical constraint. Recalling the optimization problem faced by an individual in the two-period framework mentioned above, the utility an individual receives from the difference between their income and money saved in the first period might be dependent on their income level such that, for a sufficiently low income, saving any money decreases utility.

Previous research has also shown that when faced with uncertainty about receiving a health shock in a given period, people save significantly less than the optimal strategy predicts. This under-saving behavior is persistent between two different health insurance institutions (Tracy et al., 2020). Saving decisions are significantly affected by various proxies for income uncertainty such as age, number of dependent children, education level, health status, etc., which supports the idea of precautionary saving (Guariglia, 2001).

2.3 Objective and Subjective Perspectives

The individuals that make saving decisions are humans and therefore susceptible to priming, anchoring, social and cultural norms, framing effects, and other nudges that would not have an effect on a perfectly rational economic actor (Ariely, 2010; Henrich et al., 2001; Thaler & Sunstein, 2009). Both objective and subjective perceptions of personal financial situations have a significant effect on saving decisions (Maison et al., 2019), and people can have extremely different levels of risk aversion (Maschler et al., 2013). The framework and evidence discussed previously highlights the idea that saving decisions are made as a response to uncertainty about the future and optimization problems can reflect these risks through random variables and expected utility. A saving decision can be framed as a trade-off between certain utility now via consumption of leisure and uncertain utility in the future that depends on variable income, uncertain returns on investments, and probabilistic shocks. Individual time preferences, risk aversion, and human imperfections are important considerations when analyzing individual saving decisions. The lottery faced by an individual over two periods might be perceived differently depending on framing or anchoring effects and the individual saving behavior made in response to the lottery might be different depending on subjective perceptions of wealth and probabilistic events. The two-period optimization problem can be rewritten as:

$$u_i^1(w_i^1 - s_i, x_i^1) + E[u_i^2(\widetilde{w_i^2} + s_i(1 + r_i) - \widetilde{\gamma}_i, x_i^2)]$$

where the subscript i denotes an individual's perceived values of each variable, and the unique utility functions that depend partly on individual levels of risk aversion and perception. The numbers denote the period.

3 Household Saving Decisions

To properly understand and model saving decisions, those made by members of a household must also be considered. A household is defined as two adults that each earn their own income and share money in some fashion. This is intended to represent a simple environment of a married couple making financial decisions together throughout their life. This differs from the previous case of an individual making decisions each period in a lifetime because, within a household, saving decisions directly affect both an individual's well-being and their partner's well-being.

Game theoretic models are important for understanding how individuals within the context of a household make savings decisions because much of the empirical literature focuses on aggregate household consumption rather than individual consumption (Chiappori, 1988). A theoretical framework is a solid starting place for understanding how people make repeated decisions that influence someone they might care about, and optimal solutions within these frameworks can serve as benchmarks for experimental results and policy ideals.

3.1 Non-Cooperative Approach

Taking a non-cooperative approach to modeling household saving decisions is reasonable because a cooperative approach implies the existence of exogenously enforceable contracts. While it is possible for married couples to self-impose limits on withdrawals from saving accounts and place other constraints on their financial activity, such limitations are not legally binding and can be violated or removed. In addition, since such enforceable contracts often come with significant legal, time, and transaction costs, they are not very common (Chen et al., 2001). Considering a household in which each adult decides how much money to save in a shared account that can be accessed by both partners maintains generality and allows analysis of shared saving decisions. It is worth considering that one partner might maintain a private savings account, but this does not necessitate a cooperative approach.

3.2 Bargaining

One of the fundamental changes that must be accounted for when transitioning from individual saving decisions to household ones is the introduction of bargaining. An individual that lives alone does not have to negotiate how their money is spent; they receive an income in a given period and can decide for themselves how to best allocate their money between spending and saving. By contrast, each member of a household generally has to negotiate spending and saving decisions with their partner. One member of the household might gain a significant amount of utility from contributing the maximum amount to their retirement account each year while their partner prefers to spend some of that money on a vacation. Saving decisions within a household give rise to conflicting interests, risk aversion, time preferences, and competing utility functions. A simple optimization problem that a household faces is (Martinez, 2013):

$$\Psi = \delta_1 U_1(c, l_1, l_2) + \delta_2 U_2(c, l_2, l_1)$$

where U_1 is the utility of one member of the household, δ_1 is the bargaining power of one member of the household, c is the quantity of a consumption good that can be purchased for some price, and l_1 is leisure time for one member of the household. The budget and time constraints for this system are given by (Martinez, 2013):

$$pc = w(h_1 + h_2) + Y_1 + Y_2$$

$$h_1 + l_1 = T \qquad h_2 + l_2 = T$$

where p is the price of the consumption good, w is the wage from working, h_1 is the number of hours worked by one member of the household, l_1 is leisure time for one member of the household, Y_1 is the non-working income for one member of the household, and T is the total time available in a given period. The total time in each period is necessarily identical for each person. This model can be combined with the two-period framework discussed above for an individual to create a new household optimization problem that reflects a saving decision across multiple periods:

$$\Psi_1 = \delta_1 U_1(s, c, l_1, l_2) + \delta_2 U_2(s, c, l_2, l_1)$$
$$\Psi_2 = \delta_1^2 U_1^2(c^2, l_1^2, l_2^2) + \delta_2^2 U_2^2(c^2, l_2^2, l_1^2)$$

where Ψ_1 represents household utility in the first period and s represents the amount of money that the household saves in the first period. The superscripts denote the period and are omitted from the first period for convenience. The money available to the household in the second period is necessarily a function of the amount of money saved in the first period and the solution is subject to a budget constraint for each period, each similar to the one presented above (Martinez, 2013). Each member of the household seeks to maximize $\Psi_1 + \Psi_2$. A key feature of this framework is that each household member's utility is a function of the leisure that their partner receives. This implies that each member of the household cares about their partner's well-being and utility to some extent, which is a reasonable assumption for married couples. It is worth noting that $\delta_1 + \delta_2$ must sum to one and these bargaining power parameters determine how the preferences of each individual contribute to the saving decision. If $\delta_1 = 1$, then the situation is identical to the individual environment described above and the member with all of the bargaining power will make saving decisions as if their partner does not exist.

It is clear that the relative weights of each member's bargaining power will have a significant effect on the saving decision made by the household. If one member is extremely risk averse and does not discount the future heavily, then they might want to save s_1 in a given period. If their partner is extremely risk loving and discounts the future heavily, then they might want to save $s_2 < s_1$ in the same period. The ratio of bargaining power weights, $\frac{\delta_1}{\delta_2}$ will determine where on the spectrum between s_2 and s_1 the household saves this period. Therefore, bargaining power is an extremely important parameter that contributes to the ultimate saving decision a household makes.

3.3 The Tax Model

In the model presented above, the relative ratios of the bargaining powers will determine which member's utility is prioritized, if any. If one member has a bargaining power of zero, then the entire household income will be allocated to maximize their partner's utility. For example, if the husband in a household maximizes their utility by spending all of his money on new clothes, and the wife has a bargaining power of zero, then all of their combined income will be spent on clothes. This can be seen as a tax by the wife if she does not gain any benefit from the husband buying clothes, i.e. clothes do not appear in the wife's utility function (Martinez, 2013). Similarly, if the husband maximizes utility by saving all of the household income in a given period, and the wife has no bargaining power, then the wife will see the saving as a tax on her income because she cannot spend any of it to increase her own utility. Therefore an increase in bargaining power for one member of a household implies a decrease in bargaining power for their spouse, which might be perceived as a tax on their income (Martinez, 2013).

3.4 The Unitary Model

The unitary model of the household assumes that households function as individual entities and the utility functions of people within the household are either identical or irrelevant with respect to the head of the household. In contrast to the household framework discussed above, bargaining power does not have any effect on household saving decisions in a given period under the unitary model (Martinez, 2013). Previous research has shown that monetary decisions at the household level change depending on which member receives a positive rainfall shock, which contradicts the unitary model of the household (Duflo & Udry, 2003). Further evidence shows that the well-being of children is a more significant term in women's utility functions (Martinez, 2013) and therefore an increase in a female member's bargaining power might shift saving decisions towards those that benefit their children's future. These findings imply that in order to properly model and understand household saving decisions, it is necessary to consider the preferences of each individual member rather than the household as a single entity.

3.5 The Collective Model

In contrast to the unitary model of the household, the collective model distinguishes between each member's utility function and preferences (Chiappori, 1988). This model emphasizes distinct utility functions for each member, and can allow different members of the household to have unique time preferences, levels of risk aversion, etc. Household saving decisions under the collective model allow for bargaining and are reflective of the sum of each member's bargaining power, utility functions, and so forth (Chiappori, 1988). The evidence that provides support against the unitary model necessarily supports the collective model. The collective model incorporates subjectivism and methodological individualism (Chiappori, 1988) and defines the smallest unit of economic actor as an individual, rather than a household. This is an important consideration when analyzing and modeling saving decisions because it implies that a household decision is a function of its members preferences and individual characteristics, and that some interaction between these members is necessary to achieve a decision in each period.

3.6 The Cournot-Nash Model

A more specific framework for analyzing saving decisions within the household is a two-stage game (Chen & Woolley, 2001). In the first stage, income transfers between members of the household are determined, and in the second stage, each member of the household makes their individual consumption decisions. This can be modified slightly to represent saving: in the first stage, rather than a direct income transfer, each member of the household contributes some amount of money to a shared savings account. In the second stage, both members can spend money from this account or from their unsaved portion of money. The presence of the shared account is important because it creates an additional uncertainty about the growth and existence of saved money over time: a member's partner might withdraw and spend their saved money in any given period. In this model, utility is separable between private and public goods and is given by:

$$U_i = u(x_i) + v(x_h) \tag{1}$$

where x_i is a private good and x_h represents public goods within the household (Chen & Woolley, 2001). Private goods are rivalrous such that if one member of the household purchases or consumes the good, then it does not bring any benefit to the other member. It is important to note that a good should be considered private if it does not bring any benefit to one member given their current utility function (Chen & Woolley, 2001), rather than if it could possibly bring them benefit. A new television might seem like a public good, but if one member of the household does not watch television, then this should be considered a private good. The optimization problem that each member of the household faces is (Chen & Woolley, 2001):

$$\Psi_i = U_i + \sigma_i U_j \tag{2}$$

where $\sigma_i \in [0, 1]$ represents the extent to which each member values their partner's utility. If $\sigma_i = 0$, then the member can be classified as egoistic (Chiappori, 1988) such that their partner's utility function is not considered in their optimization problem. If $\sigma_i \geq 0$, then the member is classified as altruistic such that their partner's utility function appears in their optimization problem (Chiappori, 1988). This model can be adjusted to focus on the simple choice between contributing to a shared savings account and spending on consumption, similar to the individual two-period framework. The optimization problem that each member faces can be rewritten as:

$$\Psi_i = u_i(x_i) + v_i(s_i + s_j) + \sigma_i[u_j(x_j) + v_j(s_j + s_i)] \tag{3}$$

where x_i represents individual consumption and s_i represents individual saving. Recalling the two-stage game, this can be solved using backwards induction (Chen & Woolley , 2001). Consider a member that knows their partner will spend all of their shared savings on individual consumption in the second stage of the game. Since the member knows this, they also know that any money that they save in the first stage will be spent on their partner's consumption in the second stage. If $\sigma_i = 0$ for the member, then it is a dominant strategy to not save any money in the first stage if the only vehicle for saving is a shared account. Barring such a corner equilibrium, the amount of money that one member chooses to save in the first stage should depend on how much money they expect their partner to save (Chen & Woolley, 2001). For example, if one member does not derive any utility from saving money beyond s as a household, and they expect their partner to save s, then they should not save any money in the first stage of the game.

If this two-stage game is repeated over a finite number of periods that represents the lifetime of the household, then punishments and cooperative strategies can emerge (Maschler et al., 2013). If one member of the household maximizes their single-period utility by spending all of the saved money on individual consumption, and the other member gains more utility from their own individual consumption than their partner's, then it is a Nash Equilibrium for both members to spend all of their money each period and never save any money. A Pareto-superior outcome over the lifetime can be achieved, however, if future income is uncertain and the non-selfish member agrees to save some of their income as long as their partner does not spend it all. This is similar to grim-trigger strategies that can unofficially exist between couples: it is an unspoken agreement that if one's spouse loses their retirement savings in a casino, then they will be divorced and/or financially cut off.

3.7 Uncertainty

The uncertainties and risks that each member of a household face are identical in design to the ones described in the individual model. Each member will face randomly arriving shocks, variable income, etc. One key distinction is that the loss of utility for a household member from a health or income shock can be either greater or less than the loss of utility for an individual from an equivalent shock. If both spouses are consistently earning a sufficient income for the entire household, then the loss of utility due to a negative income shock is not as severe because the other spouse can contribute to their partner's individual consumption for the duration of the shock. On the other hand, if one spouse is unemployed and the household depends on their partner's income for survival, then a negative income shock will be arguably twice as severe than it would for a single individual. For these reasons, entering into a household can either increase or decrease individual levels of risk aversion, which can change an individual's utility functions and perception of the lotteries they face when making saving decisions.

For example, a married couple might expect to have a child within the next year. Because their earnings will likely decrease as each spouse makes a trade-off between working and taking care of their new child, there is a significant uncertainty about future earnings. It is likely that the married couple will increase their savings in the current period in anticipation of a decrease in future income (Apps et al., 2014).

Another key distinction is that a household also faces uncertainty with respect to their social stability. In the context of a married couple, the relationship might end via divorce, infidelity, or due to a member's partner spending all of their retirement savings. There are two competing forces present with regards to saving decisions in this arena (Gonzalez and Ozcan, 2013). Divorce is financially and emotionally expensive, and a significant amount of money is required to complete the process. The prospect of divorce increases the probability of a negative shock in a future period, as described in the two-period framework for an individual. On the other hand, since savings are generally divided in the process of a divorce, this makes saving money more risky (Gonzalez and Ozcan, 2013) and introduces an uncertainty in the existence and longevity of saved money throughout future periods.

A quasi-natural experiment examined savings rates among married couples before and after the legalization of divorce. The results indicated a significant increase in saving behavior as a result of divorce becoming feasible (Gonzalez and Ozcan, 2013), which supports the idea of precautionary saving in the presence of future uncertainty. The legalization of divorce presented a new possible shock in the future, the probability and magnitude of which were subjective to each married individual. This is an excellent example of policy changes directly affecting saving behavior by changing the uncertainty that was introduced as random variables in the individual framework. Understanding decision and game theoretic models for how individuals and households make saving decisions can provide an understanding of how policy can be implemented to motivate more efficient ones.

4 Conclusion

Deciding how much money to save is a fundamental problem that people face throughout their lives. Decision and game theoretic models can provide insight into how people make these decisions as both individuals and members of a household. These models can elucidate which factors influence their monetary allocations and saving decisions, which can be tested against laboratory and quasi-natural experimental evidence. It is necessary to distinguish between saving decisions made by individuals and those made by members of a household because of the unique bargaining and interactions between spouses that do not exist for an individual. Although many of the underlying uncertainties and trade-offs are the same, there are additional considerations that must be accounted for. As has been demonstrated in this paper, the most convenient framework for modeling saving decisions is a two-period environment in which individuals seek to maximize their individual or household utility, and to which a variety of constraints and extensions can be added. This environment serves as a theoretical benchmark to which experimental results and policy ideals can be compared.

5 References

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