Survey Evidence on Habit Formation

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Abstract

Habit formation captures the human nature of response decrement to repetitive stimulation.[1] Models with habit formation have explained many important economic phenomena, like the equity premium puzzle. Literature, however, disagrees or is uninformative on its micro evidence. Does habit formation exist? How fast does habit change? Are additive and multiplicative habits consistent with people's behavior? How strong is habit formation relative to keeping up with the Joneses? Can habit formation explain the Easterlin paradox? To answer these five questions, I design and field a survey eliciting ten preference parameters on habit formation. I find that internal habit formation exists, as a phenomenon distinct from adjustment and cognition costs. External habit also exists but only accounts for about 17% of my habit. Habit depreciates about two-thirds per year. Both additive and multiplicative habits are rejected by the evidence. Habit formation is about as strong as keeping up with the Joneses. Combining habit formation with keeping up with the Joneses could potentially explain the Easterlin paradox.

JEL: E21, G12, D60, I31.

Keywords: Habit formation, Keeping up with the Joneses, Macro-finance, Equity premium, Easterlin paradox.

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[1]This notion of habit formation is what the current habit formation models in macroeconomics and finance are trying to capture. It is different from the day-to-day notion of the cue-routine-reward habit. As it is already a received label in the literature, I will continue referring to this phenomenon as habit formation. This definition of habit formation sets it apart from path dependence, which is sometimes confused with habit formation. It is also worth noting that habit formation is different from desensitization, which would imply reduced response to small changes. Habit formation increases response to small changes.

1 Introduction

Models with habit formation[2] have helped explain important phenomena in, among others, asset pricing, business cycles, economic growth, and international trade,[3] and is a fixture in macroeconomic models for policy analysis.[4] Yet, literature is not certain of its micro evidence (Cochrane, 2017). Micro evidence is essential in transforming "interesting calculations and properties" of models to credible predictions (Hansen and Heckman, 1996). This paper aims to provide a comprehensive set of micro evidence on habit formation, as follows.

First, habit formation exists, as a phenomenon distinct from adjustment costs and cognition costs. Depending on the source of habit, models with habit formation can be categorized into internal habit (habit formed on own past behaviors) and external habit (habit formed on other people's past behaviors). Literature investigating evidence of habit formation has mostly focused on the existence of internal habit formation and drawn mixed conclusions (see columns 1 and 2 of Table 1). Studies based on macrodata tend to find significant evidence of internal habit formation, while studies based on microdata find it to be relatively less significant. Existence of external habit formation is much less studied while a lot of theoretical papers assuming it (see, e.g., Abel, 1990; Campbell and Cochrane, 1999; Smets and Wouters, 2007; Dou et al., 2017). Without a consensus on the existence of habit formation, literature has started investigating whether habit formation is capturing other phenomena. Flavin and Nakagawa (2008) propose adjustment cost as a deeper explanation for habit formation. Matyskova et al. (2019) argue habit as a way to economize cognition costs. In this project, I will provide evidence on the existence of both internal and external habit formation and evidence that habit formation is different from adjustment and cognition costs.[5] Allowing habit to be formed both internally and externally à la Grishchenko (2010), I estimate that external habit accounts for a small portion (about 17%) of my habit.

Second, habit depreciates about two-thirds per year. Most specifications of habit formation depend on two important parameters, habit depreciation rate[6] and habit intensity. Literature has focused predominantly on the habit intensity parameter (Havranek, Rusnák and Sokolova, 2017; column 3 of Table 1) while treating the habit depreciation rate largely as a free parameter whose value is often chosen to improve model fit with data. Two potential reasons are the relative lack

[2]Throughout this paper, habit refers to (real) total consumption habit. There is deep-habit literature that assumes people form habit on individual varieties of consumption, which is not the focus of this project.

[3]E.g., equity premium puzzle and stock market behavior (Constantinides, 1990; Campbell and Cochrane, 1999); excess smoothness and excess sensitivity of consumption (Fuhrer, 2000); high growth causes high saving (Carroll, Overland and Weil, 2000); simultaneous decline in investment and current account (Cardi and Müller, 2011).

[4]See, e.g., Smets and Wouters (2007); Christiano, Eichenbaum and Trabandt (2015); Dou et al. (2017).

[5]Biologists have found evidence on habit formation in humans and all animals, including single-celled amoeba that does not have a nervous system (Folger, 1926). My result implies that people form habits for reasons beyond adjustment and cognition costs. For example, Rayo and Becker (2007) argue from the evolutionary perspective that habituating living standards makes us more motivated to strive for more, which potentially helps with survival.

[6]I focus on depreciation rate rather than catch-up rate because the latter varies under different normalizations of habit while the former is invariant to such normalization.

of evidence on this parameter and the massive disagreement between the few existing micro and macro estimates (column 4 of Table 1). I provide a micro estimate that is much closer to, though still relatively far away, from typical macro estimates. To illustrate the importance of this parameter, I show that simply changing the value of this parameter can significantly reduce the performance of some habit formation model.

Third, neither additive nor multiplicative habit is consistent with people's behaviors. Almost all current habit formation models in the literature are assuming either one of these two habit utility functions. The conclusions drawn from these studies are, therefore, joint tests and estimates with these specifications. In a general utility function naturally nesting these two formulations, I propose and implement four tests on the micro validity of the preference specifications. I find that both types of habit utility function fail the tests by large margins. Even though these two particular specifications are not consistent with the evidence, estimates of the signs of utility derivatives are consistent with habit formation.[7]

Fourth, the effect of habit formation on utility is about as strong as that of keeping up with the Joneses. As two important interdependent preferences, keeping up with the Joneses allows interdependence across individuals, while habit formation allows interdependence across both time (in internal and external habits) and individuals (in external habit). Literature finds a strong effect of keeping up with the Joneses (Luttmer, 2005; Lewbel et al., 2018; De Giorgi, Frederiksen and Pistaferri, 2019) but disagrees on the relative strength of these two phenomena. Ravina (2007) finds habit formation to be about 70% stronger than keeping up with the Joneses, while Alvarez-Cuadrado, Casado and Labeaga (2015) conclude that internal habit formation is about just as strong as keeping up with the Joneses. I investigate this question without specifying particular functional forms for utility function and the speed that habit depreciates.

Fifth, habit formation joining forces with keeping up with the Joneses could generate the income-happiness pattern of the Easterlin paradox. Easterlin (1973, 1974) highlights the tension between cross-sectional positive correlation and time-series zero correlation between happiness and income and propose keeping up with the Joneses as an explanation for its effect on averaging happiness. As happiness data accumulates over time, the literature realizes the zero correlation tends to hold only in the long-run while the short-run correlation is generally positive (Stevenson and Wolfers, 2008; Sacks, Stevenson and Wolfers, 2012; Easterlin, 2017).[8] Habit formation has been proposed as a potential explanation to the original version of the paradox[9] (Easterlin, 1995) and in particular, to the relatively newly discovered temporal heterogeneity of the correlation (Clark, Frijters and Shields, 2008; Clark, 2016). To the best of my knowledge, evidence

[7]That is, $u_{CH} > 0$ and $u_{HH} < 0$.

[8]I am aware of the controversy around the existence of the paradox. My purpose here is not to defend the paradox, as I do not provide new evidence on happiness measures, but to see how potentially can habit formation (and keeping up with the Joneses) affect the relationship between income or consumption and happiness.

[9]Kimball and Willis (2006) propose as a potential explanation of the paradox that happiness is time-intensive. They also survey several other potential explanations. In this project, I focus on the effects of habit formation and keeping up with the Joneses.

on whether habit formation can actually fit in this shoe is absent from the literature. Utilizing my aforementioned comprehensive set of evidence on habit formation, I conduct a semi-structural simulation and find that when coupling with keeping up with the Joneses, habit formation is able to generate the observed patterns of income and happiness across all the dimensions: cross-section, short-run, and long-run.

Providing this extensive set of evidence faces two challenges. First, I need a framework flexible enough to nest all current habit formation models that are heterogeneous along many dimensions while remaining agnostic of the existence of habit formation. Second, jointly estimating all the preference parameters requires variations that, to the best of my knowledge, do not exist in reality. To tackle the first difficulty, I take a flexible habit formation model with assumptions of minimal interference with the evidence I am providing. To tackle the second difficulty, I employ the method of eliciting preference parameters using hypothetical situations. While having its own limitations (response errors and biases),[10] this method has the advantages of creating variations absent in reality and of avoiding potential systematic biases of incentivized choices (e.g., misperceptions and lack of information).[11] The application of this method in economics can be traced back to at least Thurstone (1931) and has been widely used in eliciting reduced-form preference parameters in environmental economics, experimental economics, and health economics (Johnston et al., 2017; Ameriks et al., 2019; Jha and Shayo, 2019). The use of this method in eliciting structural preference parameters started since at least Barsky et al. (1997) and is commonly used thereafter in the literature (see, e.g., Kapteyn and Teppa, 2003; Sahm, 2007; Kimball, Sahm and Shapiro, 2008, 2009; Benjamin et al., 2014; Kimball et al., 2015; Benjamin et al., 2019).

In the flexible habit formation model, I identify ten preference parameters[12] that are instrumental to the above set of evidence on habit formation. Guided by the identification, I design and field a survey eliciting these preference parameters. Using Hamiltonian Monte Carlo, I jointly estimate all the parameters.

I present the flexible habit model and the survey instrument in section 2. Then I summarize the data and the statistical model that will be applied to the data (section 3). Section 4 contains the elicitation and estimate of each preference parameter of interest and how the estimates inform us of habit formation. I conduct the simulation on the Easterlin paradox in section 5. I discuss and check the robustness of my results in section 6. Section 7 concludes.

[10] See also Diamond and Hausman (1994).

[11] See also Manski (2000).

[12] They are habit depreciation rate, time discount rate, external habit mixture coefficient, all ratios of utility derivatives up to the second-order, and two quantities relating to the existence of internal and external habits.

Table 1: Estimates of Habit Parameters in Selected Literature

Preference parameters in the table are from some versions of following habit formation model:

$$u(C,H) = \begin{cases} v(C-\alpha H) & \text{Additive Habit} \\ v(C/H^{\alpha}) & \text{Multiplicative Habit} \end{cases} \quad \text{s.t. } \dot{H} = \theta\left((1-\omega)C + \omega C_{others} - H\right)$$

where α is habit intensity, θ habit depreciation rate, and ω external habit mixture coefficient.

Study	Internal Habit	External Habit	α	θ[3]	ω	Additive or Multiplicative
A. Microdata						
Naik, Moore (1996)	Y	*(N)*	0.081***	*(Y)*	*(0)*	*(A)*
Dynan (2000)	N	*(N)*	-0.038	*(Y)*	*(0)*	*(A)*
Guariglia, Rossi (2002)	N	*(N)*	-0.272***	*(Y)*	*(0)*	*(A)*
Lupton (2002)	Y	*(N)*	0.225***	9.2%/Y***	*(0)*	*(A)*
Kapteyn, Teppa (2003)	Y	*(N)*	0.777***	[4]	*(0)*	*(M)*
Rhee (2004)	Y, N[1]	*(N)*	0.6	*(Y)*	*(0)*	*(A)*
Ravina (2007)	Y	N	0.503***	*(Q)*	0.025[2]	*(A, M)*
Browning, Collado (2007)	Y, N[1]	*(N)*	0.01-0.14	*(Q)*	*(0)*	*(A)*
Alessie, Teppa (2010)	Y	*(N)*	0.211**	*(Y)*	*(0)*	*(A)*
Iwamoto (2013)	N	*(N)*	-0.3787***	*(Y)*	*(0)*	*(A)*
Khanal et al. (2018)	Y	*(N)*	0.545***	*(Y)*	*(0)*	*(A)*
⋮ ($\geq$ 10 studies)	⋮	⋮	⋮	⋮	⋮	⋮
B. Macrodata						
Ferson, Constantinides (1991)	Y	*(N)*	0.64-0.97***	*(M, Q, Y)*	*(0)*	*(A)*
Fuhrer (2000)	Y	*(N)*	0.80***	99.9%/Q***	*(0)*	*(M)*
Stock, Wright (2000)	Y, N[1]	*(N)*	-	*(M, Y)*	*(0)*	*(A)*
Smets, Wouters (2003)	*(N)*	Y	0.573***	*(Q)*	*(1)*	*(A)*
Lubik, Schorfheide (2004)	Y	*(N)*	0.57***	*(Q)*	*(0)*	*(M)*
Christiano et al. (2005)	Y	*(N)*	0.65***	*(Q)*	*(0)*	*(A)*
Smets, Wouters (2007)	*(N)*	Y	0.71***	*(Q)*	*(1)*	*(A)*
Adolfson et al. (2007)	Y	*(N)*	0.650***	*(Q)*	*(0)*	*(A)*
Korniotis (2010)	N	Y	0.33[2]	*(Y)*	0.79[2]	*(A)*
Grishchenko (2010)	Y	N	0.895[2]	70.7%/Q***	0.000***	*(A)*
Altig et al. (2011)	Y	*(N)*	0.76***	*(Q)*	*(1)*	*(A)*
⋮ ($\geq$ 65 studies)	⋮	⋮	⋮	⋮	⋮	⋮

Notes: The studies are selected based on citation, publication year, and number of parameters estimated. Characters in parenthesis and intalics are assumed parameter values. 1: depends on goods or time horizon; 2: implied estimates; 3: M/Q/Y habit depreciates fully at end of a month/quarter/year; 4: geometric habit evolution speed: 0.071 (0.007). Significance levels: ** 5%, *** 1%.

2 Methodology

2.1 Habit Formation Model

The breadth of the questions this paper intends to answer requires the habit model to be as general as possible so that it nests all the specifications of interest. Generality means as few assumptions as possible. Still, enough structure must be put in place so that the model is useful for the purposes of this paper.

The agent maximizes the expected utility of

$$\mathbb{E}_0 \int_0^\infty e^{-\rho t} u\left(C\left(t\right), H\left(t\right)\right) dt$$

where C is individual spending, H habit, and ρ time discount rate. Henceforth the time index will be omitted when there is no ambiguity in doing so. I maintain expected utility and exponential time discounting.[13] As is ubiquitous in the literature, I require that the utility function to be analytic and to satisfy positive monotonicity of consumption ($u_C > 0$) and diminishing marginal utility of consumption ($u_{CC} < 0$). These assumptions aid identification and estimation without interfering the evidence this paper is providing. For example, I leave open whether habit actually affects the utility function and the sign and magnitude of any derivative of the utility function with respect to habit. I allow the respondent's utility to depend on other variables (e.g., labor), but since they will be kept constant in the survey, abstracting from explicitly listing them as the arguments of the utility function results in no loss of generality. In some survey questions I do vary things other than self spending and habit (e.g., other people's spending). When I do so, I will explicitly show the variables in the utility function. For clarity, I will save the details for relevant contexts.

I assume habit evolves according to

$$\dot{H} = \theta\left(C - H\right)$$

where θ is the habit depreciate rate. This formulation has been in the literature since at least Houthakker and Taylor (1970) and is the most commonly used habit evolution equation in the literature. Slightly different formulations of the evolution are used. But the difference either is simply a rescaling of the unit of habit (e.g. Constantinides, 1990) or disappears in steady state (e.g. Campbell and Cochrane, 1999). For general habit evolutions that potentially are nonlinear, I show that they are equivalent to this linear habit evolution under reasonable conditions.[14] I choose this habit evolution also because of its natural unit, same as that of consumption. For example, if a person has been consuming \$5,000 per month for as long as she can remember, then her habit is also \$5,000 per month.

[13] Nearly all current habit formation models make these two assumptions.

[14] See section B of the appendix for the proof. The basic intuition of the proof is that the nonlinearity can be "transported" to the utility function which is agnostic of how habit affects it.

To answer the motivating questions, I need to see if the utility function depends on habit. If habit exists, I also need to know the values of the explicit parameters, θ and ρ, all the ratios of utility derivatives up to the second order ($-\frac{u_H}{u_C}$, $\frac{Hu_{HH}}{u_H}$, $\frac{u_{CH}}{u_{HH}}$, and $\frac{u_{CC}}{u_{HH}}$), and, in the extended models,[15] external habit mixture coefficient and the strength of habit formation relative to keeping up with the Joneses.

2.2 Survey Overview

To elicit the preference parameters, I specify simple hypothetical situations that identify the preference parameters of interest while controlling for potential confounding factors and response errors and biases. I implement the hypothetical questions in a survey.

My survey starts with a preamble module that specifies the basic hypothetical situation and instructs the respondents on reading monthly spending graphs.[16] Nine core modules follow to elicit the preference parameters of interest.

The hypothetical situation is designed to be as simple as possible while still allows me to elicit what I am interested in and to avoid potential confounding factors that plague traditional data. The key is not realism, but simplicity. If the situation is simple enough, though hypothetical, people will be able to understand it. In particular, I want to free respondents from worrying about changes to purchasing power of their money, about durable goods, and about changes in preferences. The exact wording of the hypothetical situation in the survey is the following.

> Please answer all survey questions under the following hypothetical situation:
>
> - There is no inflation and prices of everything stay the same over time.
> - You rent the durable goods you consume, including residence, furniture, car, etc.
> - Things you want don't change over time.
> - People not mentioned in questions always spend $5,000 per month.
> - Everything else unmentioned in the questions is and stays the same.

I test respondents' understanding of this hypothetical situation. Only those who pass the test are able to proceed to remaining modules in the survey.

The respondents did not know that they were answering a survey about habit formation. I told the respondents that the survey is about spending behavior. I do this for two reasons. First, to avoid potential confusion. More likely than not, a typical respondent does not know what the consumption habit is as we economists call it. Second, to avoid potential biases. I cannot prime them with habit formation while I want to test the very existence of it.

[15] See sections 4.4 and 4.5.

[16] For details on this instruction, see section F of the appendix.

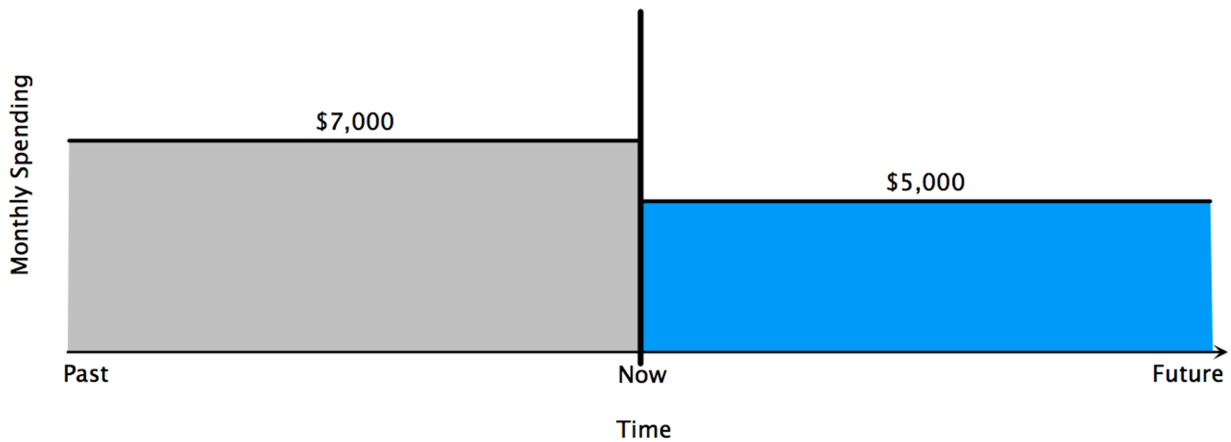


Figure 1: A Typical Monthly Spending Graph

Because I am interested in how habit affects people's well being and how habit changes in response to spending changes, I vary people's past and future spending profiles to elicit the preference parameters of interest. I create variations in both past and future spending paths because habit reveals itself in the way that the past affects the future. Once spending paths are specified, income does not affect utility. For this reason, I do not specify the income process except to tell the respondents that they can afford the spending profiles I specified. To make the representation of a spending profile intuitive and to simplify comparison across several of them, I draw a spending path in, as I call it, a monthly spending graph (Figure 1). The horizontal axis is time: past on the left, now in the middle, and future on the right. The bars on the graph represent monthly spending. The bars are drawn to scale and colored differently to help distinguish time horizons. In the example of Figure 1, the spending path represents spending $7,000 per month in the past until now and $5,000 per month in the future starting now. The respondents went through a tutorial and a test on reading the monthly spending graphs before answering questions in the core modules.

To alleviate the concern that each person can have only one past spending path in reality, I invoke the metaphor of parallel universes. In the parallel universes, everything is exactly the same except for the spending profiles. I then ask the respondents which universe brings them a better future experience: how they feel in the future starting now.

Despite their advantages, surveys can be subject to response errors and biases. But it is always good to have more perspectives getting at the same question. This is especially valuable when traditional methods suffer from major limitations (e.g., alternative explanations) and papers using them disagree with each other. I build into the survey various details to minimize response errors and biases (see Figures 2 and 3 for screenshots of a typical survey question). For example, to reinforce the idea that the only variation between universes is in spending paths, I emphasize it at the start of every set of questions.[17] To help the respondents compare different spending paths, I tell them in what time horizon the paths differ. To help them distinguish past experience from future experience, I allow them to express views on both experiences. I also reiterate definitions of the experiences of interest and highlight the words past and future to further remind the respondents of which experience the question is about. To avoid respondents accidentally clicking an option different from the one they wanted to choose, I build the monthly spending graphs into the clickable choices. To inform them even further which choice they are choosing, I slightly darken the background of an option when their mouses hover over it and completely darken the option of choice (Figure 4). I deal with remaining response errors through a statistical model.[18]

To make sure that my respondents are paying attention, I have a set of attention checks, ranging from explicit ones, like testing understanding of the hypothetical situation, to implicit ones, like time spent on the survey, questions gauging their understanding of the hypothetical situation again at the end of the survey, and cross-wave consistency of their answers to the demographic questions. To encourage effort, I told the respondents about the existence of such attention checks but did not tell them where they are and what they look like in the survey. Also, to encourage more effort, I told them at the introduction section of the survey that a small ($1) lottery with a winning chance of 1 to 100 will be paid to respondents of high-quality responses.[19]

To further minimize potential response errors and biases, I conducted two waves of the survey and changed the sequence of core modules and reversed the order of choices for questions in the second wave.

The survey responses do not directly tell me what the preference parameters are, but they give me clues with which I can uncover the preference parameters. In essence, the uncovering process is a mathematical proof that translates survey responses into values of the preference parameters of interest. Based on how accurate the translation is, I will distinguish different orders of elicitation. For example, first-order elicitation means that the translation error will be up to the remainder of a first-order Taylor series, while exact elicitation means that there will not be any translation error. To elicit some preference parameters under the general habit model, translation error is unavoidable but my estimates show that even the first-order elicited preference parameter can be very close to that estimated using traditional methods.[20] The elicitation varies from one preference parameter to another.

[17] A set of questions corresponds to one or two preference parameters of interest and usually consists of 2 to 3 subquestions.

[18] See section 3 for details.

[19] Of the 515 responses I collected, 6 respondents were paid this small lottery.

[20] See section 4.5 for details.

- Imagine that Universes One and Two are identical except your monthly spending in the 'past'.
- Remember that past experience is how you felt about the 'past' until 'now'.

Which universe gave you a better **past** experience?

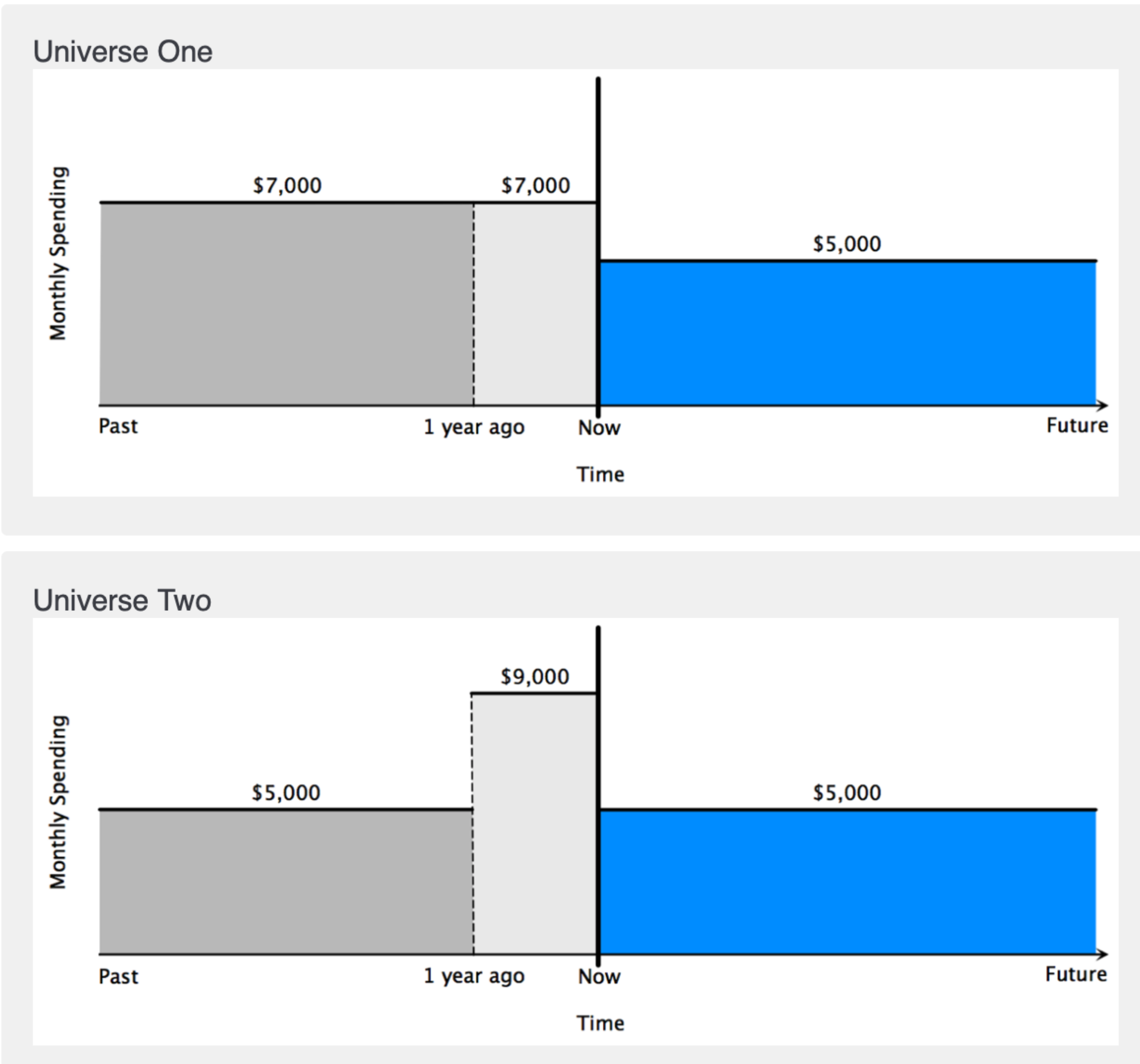


Figure 2: A Typical Survey Question (Part 1)

- Remember that future experience is how you feel about the 'future' starting 'now'.

Which universe will give you a better **future** experience?

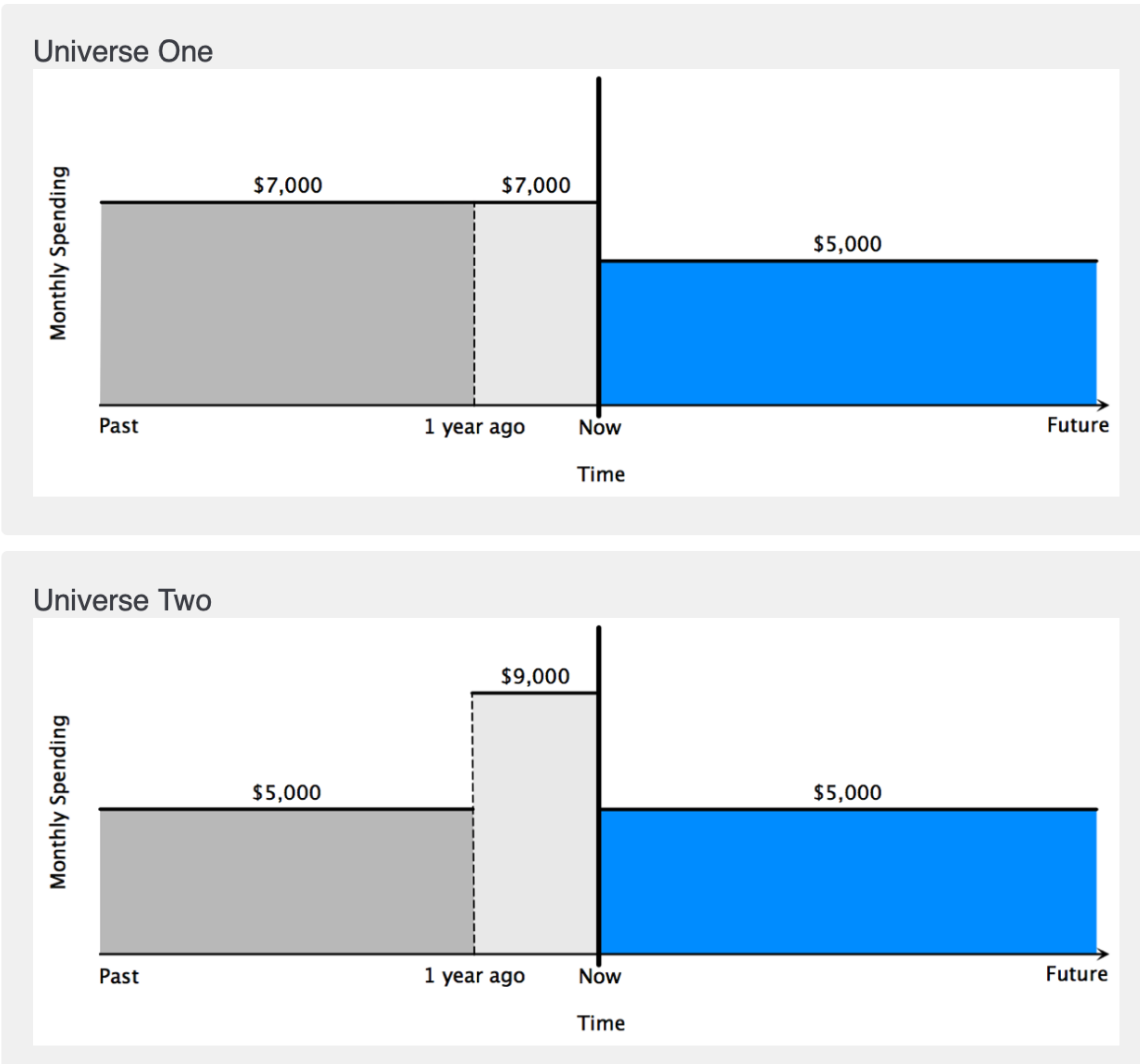


Figure 3: A Typical Survey Question (Part 2)

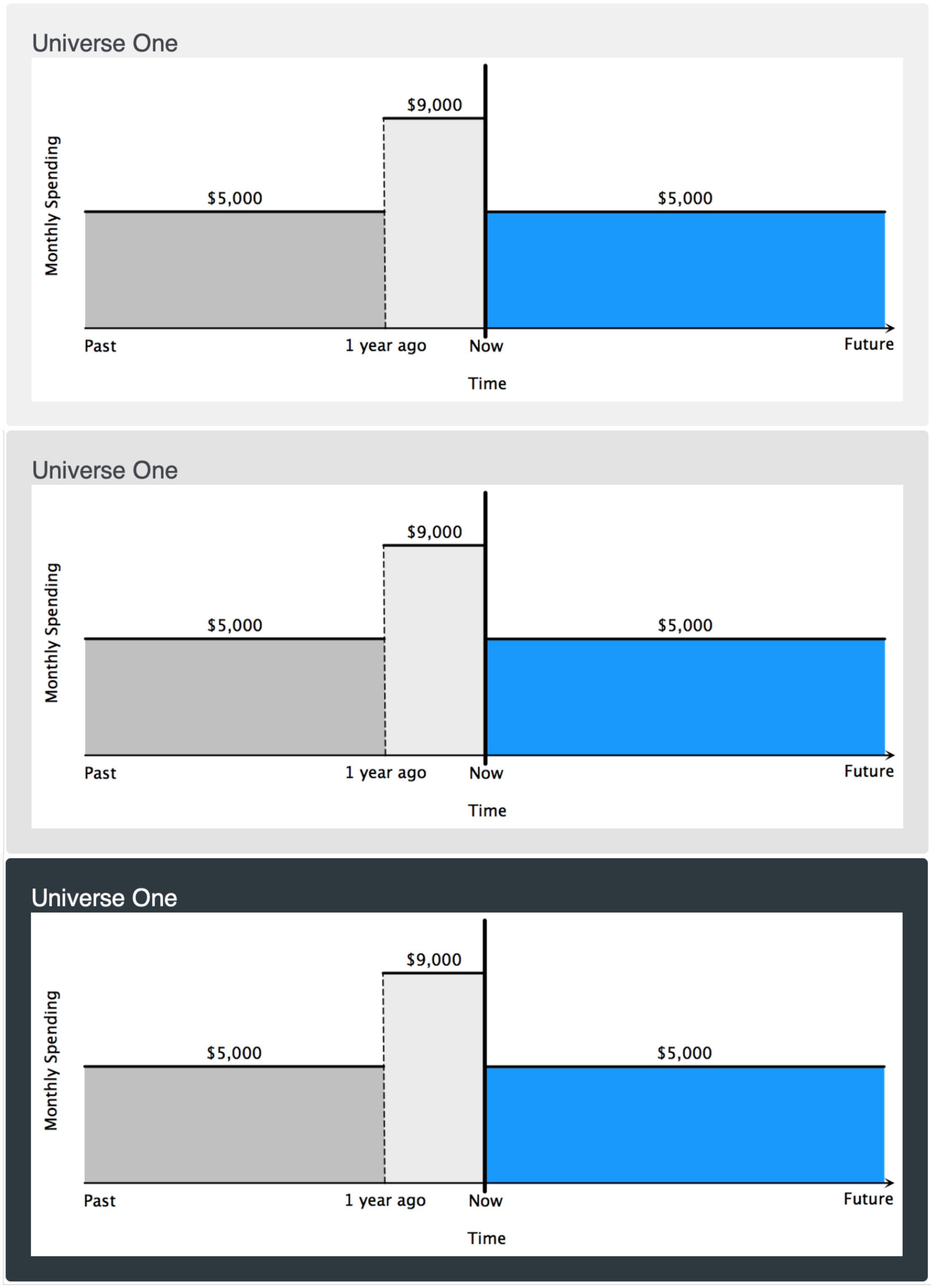


Figure 4: Option Appearances (Top to Bottom: Initial, Hover, Click)

Table 2: Demographic Statistics

	First Wave	Second Wave	U.S.
Age, median	38	37	38
Household income, median	\$50,000 - \$60,000	\$50,000 - \$60,000	\$57,652
Female percentage	53.2%	47.9%	50.8%
Household size, mean	2.66	2.70	2.63
Time on survey, mean	28' 6"	25' 32"	

Notes: Household income is annual. The last column has the counterparts of the statistics at the U.S. national level. The sources of the U.S. statistics are 2018 Population Estimates (for age and female percentage), 2017 American Community Survey, and 2017 Puerto Rico Community Survey (for household income and size), all from U.S. Census Bureau.

3 Data and Statistical Model

3.1 Data

I conducted two waves of the survey on Amazon Mechanical Turk.[21] Although this sample is less representative of the US population than national probability samples like Health and Retirement Study and Panel Study of Income Dynamics, it is more representative than lab samples (Berinsky, Huber and Lenz, 2012). Johnson and Ryan (2018) show that this sample can provide consistent and economically meaningful data. Many economics papers have utilized this sample (see, e.g., Oster, Shoulson and Dorsey, 2013; Kuziemko et al., 2015; Bordalo et al., 2016; Cavallo, 2017; Martínez-Marquina, Niederle and Vespa, 2019; Benjamin et al., 2019).

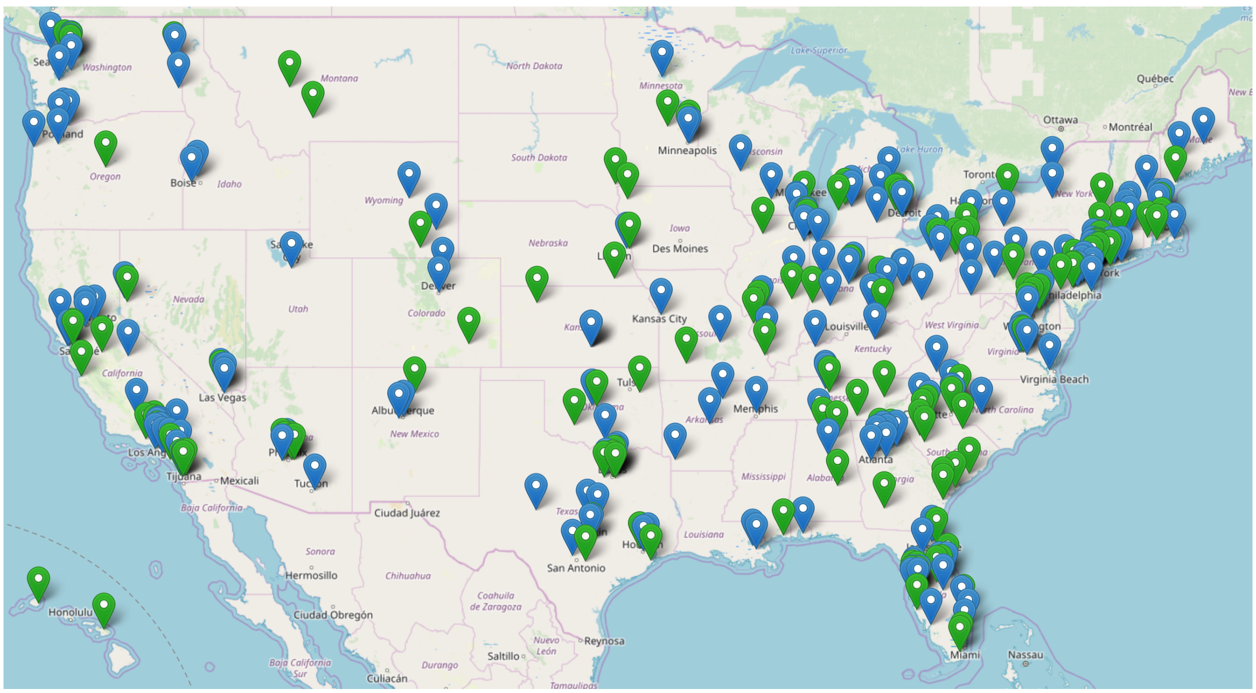
I restrict my respondents to U.S. residents. From the 301 first-wave respondents who expressed a willingness to participate in future studies, I randomly drew 200 respondents to participate in the second wave and got a response rate of about 75%. After excluding respondents located outside of the U.S., submitted duplicate responses, and sped through the survey, I am left with 348 and 140 valid responses from the two waves, respectively, by respondents across the U.S. (Figure 5).

In the survey, I collected demographic information on age, gender, household income, and household size. These sample characteristics are close to the national counterparts (Table 2).

At the time of the survey, a typical respondent is about 38 years old, lives with another person or two people in a household of an annual income of the range \$50,000 to \$60,000, is slightly more likely to be female if participate in only the first wave and slightly more likely to be male if participate in both waves, and spent about slightly less than half an hour on the survey.

I have nine core survey modules each corresponds to one or two preference parameters of interest. Eight of the ten elicited preference parameters can be identified to scale and are estimated jointly for accuracy. As a result, response frequencies of individual parameters alone are not

[21] The first wave was conducted on July 23, 2018 and the second wave on August 11, 2018.



Notes: Green markers indicate locations of respondents participating in both waves while blue markers only in first wave.

Figure 5: Locations of the Respondents

particularly informative, which are therefore relegated to the appendix (Table 28). The response frequencies of parameters identifiable to sign only are reported in section 4.

3.2 Statistical Model

I minimize response errors and biases in the survey design. In addition to purging invalid responses from the sample, I deal with remaining response errors through the following statistical model.

I model an observed response for preference parameter x of individual i in wave w, $X_{i,w}$, as

$$X_{i,w} = \sum_k k \cdot 1\left(T_{k,\tilde{x}} \leq \tilde{x}_{i,w} \leq T_{k+1,\tilde{x}}\right)$$

where the unobserved parameter value can be measured with error,

$$\tilde{x}_{i,w} = x_i + \varepsilon_{i,x,w}$$

, and $T_{\{k\},\tilde{x}}$ is the sequence of known thresholds informed by the elicitation of the parameter. The true parameter value for individual i, x_i, is drawn from $\mathscr{N}(\mu_x, \sigma_x^2)$. The individual-parameter-wave-specific response error $\varepsilon_{i,x,w}$ is drawn from $\mathscr{N}(0, \varsigma_{x,w}^2)$ independently of the true parameter value. In the robustness section, I allow the mean of the response errors to be non-zero and vary across waves. I find that the estimates of the non-zero means are indistinguishable from zero and that the estimates of the preference parameters are not significantly different from those under the zero-mean response error specification here. I assume that the parameters are drawn independently within a respondent. Because my respondents spread across the U.S. (Figure 5) and most likely did not know each other, I assume that responses are independent across respondents.

Allowing the response error to be persistent across waves (i.e., $Cov(\varepsilon_{i,x,1}, \varepsilon_{i,x,2}) = \sigma_{\varepsilon_x}^2 > 0$ and $\varsigma_{x,w}^2 = \sigma_{\varepsilon_x}^2 + \sigma_{\varepsilon_{x,w}}^2$), I arrive at the joint distribution of respondent i's parameter x in the two waves of survey

$$\begin{bmatrix} \tilde{x}_{i,1} \\ \tilde{x}_{i,2} \end{bmatrix} \sim \mathscr{N}\left(\begin{bmatrix} \mu_x \\ \mu_x \end{bmatrix}, \begin{bmatrix} \sigma_x^2 + \sigma_{\varepsilon_x}^2 + \sigma_{\varepsilon_{x,1}}^2 & \sigma_x^2 + \sigma_{\varepsilon_x}^2 \\ \sigma_x^2 + \sigma_{\varepsilon_x}^2 & \sigma_x^2 + \sigma_{\varepsilon_x}^2 + \sigma_{\varepsilon_{x,2}}^2 \end{bmatrix} \right)$$

.

In section A of the appendix, I prove that the individuals' parameter values aggregate to the mean for the representative agent. That is,

$$x_R = \frac{1}{N} \sum_i x_i$$

where x_R is the value of the representative agent's parameter x. Given that almost all current habit formation models assume a representative agent, I will focus on the implication of my estimates for a representative agent model with habit formation. Since $x_R = \mu_x$, my interest is on μ_x.

To increase accuracy, I estimate the parameters jointly. I use the Markov Chain Monte Carlo method Hamiltonian Monte Carlo that excels at high dimensional estimation. I choose uniform distributions as priors for the parameters, not only to let data speak as much as possible, but also establishes the equivalence between my maximum a posteriori (MAP) estimates and maximum likelihood estimates. I run ten Markov chains initialized from random diffuse starting points and collect 15000 iterations of warmup and 25000 draws of sampling. I will report all three Bayesian point estimators[22] and the highest posterior density or mass interval (HPDI or HPMI).

4 Elicitation and Estimation

In this section, I show how the design of the survey and the estimates of preference parameters answer the questions on the micro evidence of habit formation. I break discussion of the existence of internal habit formation and external habit formation into two parts, for the latter involves expanding the model which is best done after discussing survey questions that does not require the expansion. First, let us look at existence of internal habit formation, habit depreciation speed, and additive versus multiplicative habits. Then, we will turn to the existence of external habit formation and the relative strength of habit formation and keeping up with the Joneses.

4.1 Existence of Internal Habit Formation

The fundamental idea of habit formation is diminishing response to a repetitive stimulus. In the case of internal habit formation, the higher is a person's past consumption the lower is her future utility (response). Since habit is a measure of the intensity and persistence of past stimulation (consumption), it increases with consumption (stimulation). That is, habit formation is consistent with $Q_H \equiv u(C, H + \Delta h) - u(C, H) < 0$, but not with $Q_H \geq 0$, for $\Delta h > 0$.

To elicit the sign of Q_H, I vary the respondent's past spending profile so that the respondent's current habit varies across the universes. I choose a common future spending for all the universes so that the only difference between the universes is the current level of habit when it comes to future experience. It is worth emphasizing again that I did not prime the respondents with habit formation in the survey and I do not make any assumption about the signs of derivatives of the utility function with respect to habit.

The survey question asks the respondents to pick the monthly spending graph that gives a better future experience from Figure 6. Preferring a universe with less past spending over one with higher past spending implies $Q_H < 0$. The responses to this question show that the average respondent chooses Universe One (Table 3), consistent with the existence of habit formation for the representative agent. My estimate confirms this (Table 4).

By monotonicity of the utility function,[23] $Q_H < 0$ implies $u_H < 0$.

This survey question also enables me to distinguish between adjustment costs and internal habit formation. Flavin and Nakagawa (2008) argue that the adjustment cost of consumption commit-

[22] MAP together with posterior mean and posterior median.

[23] This is implied by the analyticity of the utility function (Debreu, 1972).

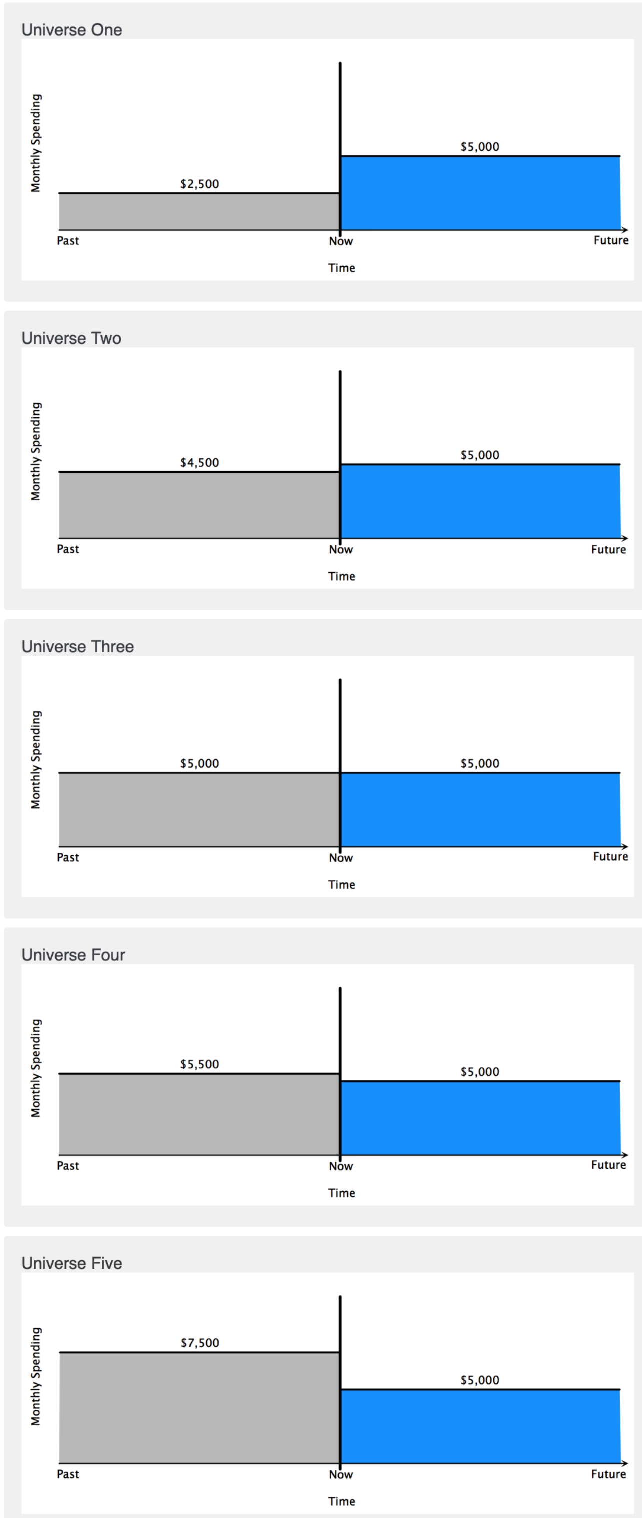


Figure 6: Monthly Spending Graphs: Existence of Habit Formation

Table 3: Response Frequency (Percentage) of Existence of Habit Formation

Universe	1	2	3	4	5
1st Wave	56	3	9	1	30
2nd Wave	60	2	6	1	30

Table 4: Estimate of Sign of Q_H

	MAP	Mean	Median	99% HPMI
$\mathrm{sgn}(Q_H)$	-1.00	-1.00	-1.00	[-1.00, -1.00]

ments match data better and raise the possibility that adjustment cost is the structural explanation of habit formation. Chetty and Szeidl (2016) show that difference between the two models matters for welfare and policy, because consumption commitment can be abandoned quickly while habit cannot. In the survey, I explicitly avoid consumption commitments by asking the respondents to rent durable goods they consume. So there shouldn't be any adjustment costs. In this situation, if the respondent's behavior still exhibits habit formation (i.e. choosing Universe One) then habit formation and adjustment costs are two separate phenomena and therefore the latter is not a deeper cause of the former. Provided that adjustment cost is the deeper cause of habit formation, I would see people choose all the universes uniformly absent of any adjustment costs. I, however, did not find this. Moreover, even if there is adjustment costs in the consumption of nondurable good, the respondent should choose Universe Three which involves the least amount of adjustment cost because of the same level of consumption spending in both the past and the future. Again, data does not support this.

Cognition costs also cannot generate the response pattern I observe in the survey responses. If one models cognition costs as the costs associated with coming up with the optimal path on spending, the respondents should choose the five universes uniformly because the consumption path is already specified in each universe and therefore require no cost to come up with it. If one models cognition costs as the cost associated with changing consumption path,[24] the respondents should choose Universe Three over others because it involves the least change of spending and therefore the least level of cognition costs. Whichever way one models cognition costs, the responses would be dramatically different from mine. As a clarification of above discussion, the fact that my evidence support the existence of habit formation being separate from adjustment and cognition costs does not reject the existence of adjustment and cognition costs. What is shown is that habit formation exists separately from adjustment and cognition costs and therefore that the latter cannot be deeper causes of the former.

[24] E.g. one may need to spend some cognition efforts to adjust her spending to a level different from her previous level.

Table 5: Estimates of Habit Depreciation Speed

	MAP	Mean	Median	95% HPDI
Habit Depreciation Rate	1.11	1.11	1.11	[0.89, 1.31]
Habit Depreciation Factor	0.67	0.67	0.67	[0.60, 0.74]

4.2 Habit Depreciation Speed

To find out how fast habit depreciates I elicit and estimate the parameter θ as in $\dot{H} = \theta(C - H)$. In the survey question (Figure 3), I vary the time structure of past spending so that the resulting difference in current levels of habit enables the elicitation of θ (Proposition 1).

Proposition 1. *Under exact elicitation, a respondent chooses Universe One over Universe Two for a better future experience in the habit depreciation rate question if* $\theta > -\ln\left(1 - \frac{\Delta C_{U1}}{\Delta C_{U2}}\right)$.

All proofs are in section D of the appendix.

In Proposition 1, ΔC_{U1} (ΔC_{U2}) is the difference between the monthly spending in Universe One (Universe Two) and the baseline monthly spending, \$5,000 per month. In the example of Figure 3, $\Delta C_{U1} = \$2,000$ and $\Delta C_{U2} = \$4,000$. Thus, this survey question separates the values of θ into two complementary intervals: $\theta > \ln 2$ and $\theta < \ln 2$.[25] I use unfolding brackets to further pin down a finer range of θ for each possible response. Each respondent will answer one to two follow-up questions that put her answer into one of the six brackets in Figure 7. I estimate a depreciation rate of 1.11, which implies that habit depreciates 67% annually (Table 5). The annual depreciation rate of 67% implies that habit will have changed about 89% after two years, which is remarkably close to the findings in the psychology literature that income adaptation takes about two years.[26]

The speed at which habit depreciates matters. In a typical additive habit model, the faster habit depreciates, the less risk-averse the agents of the model become. In the most cited paper using a habit formation model, Campbell and Cochrane (1999)[27] also employ the additive habit[28]. In their model, however, the faster habit depreciates the more risk averse people are. The reason is that in their model, the implied steady-state habit intensity[29] is not constant, but increases with the habit depreciation rate. The higher the habit intensity is, the more likely a same risky fluctuation of consumption causes consumption to fall below the habit intensity adjusted level of habit and thus the more risk-averse a person becomes. The net effect of a higher depreciation rate in their model is

[25] I abstract from $\theta = \ln 2$ because θ has a probability of 0 to be exactly equal to $\ln 2$. The threshold of $\ln 2$ in continuous time corresponds to a threshold of 0.5 in discrete time.

[26] See Clark, Frijters and Shields (2008) for a review.

[27] Google scholar reports that this paper has been cited by 4,895 times as of October 16, 2019.

[28] They specified a nonlinear evolution for habit, surplus consumption ratio to be precise. It coincides with the linear habit evolution specified here in steady state.

[29] Under additive habit, the instantaneous utility is $u(C - \alpha H)$ where α is the habit intensity parameter. In Campbell and Cochrane (1999)'s notation $X_t = \alpha_t H_t$. The implied steady-state habit intensity is therefore X_t / C_t.

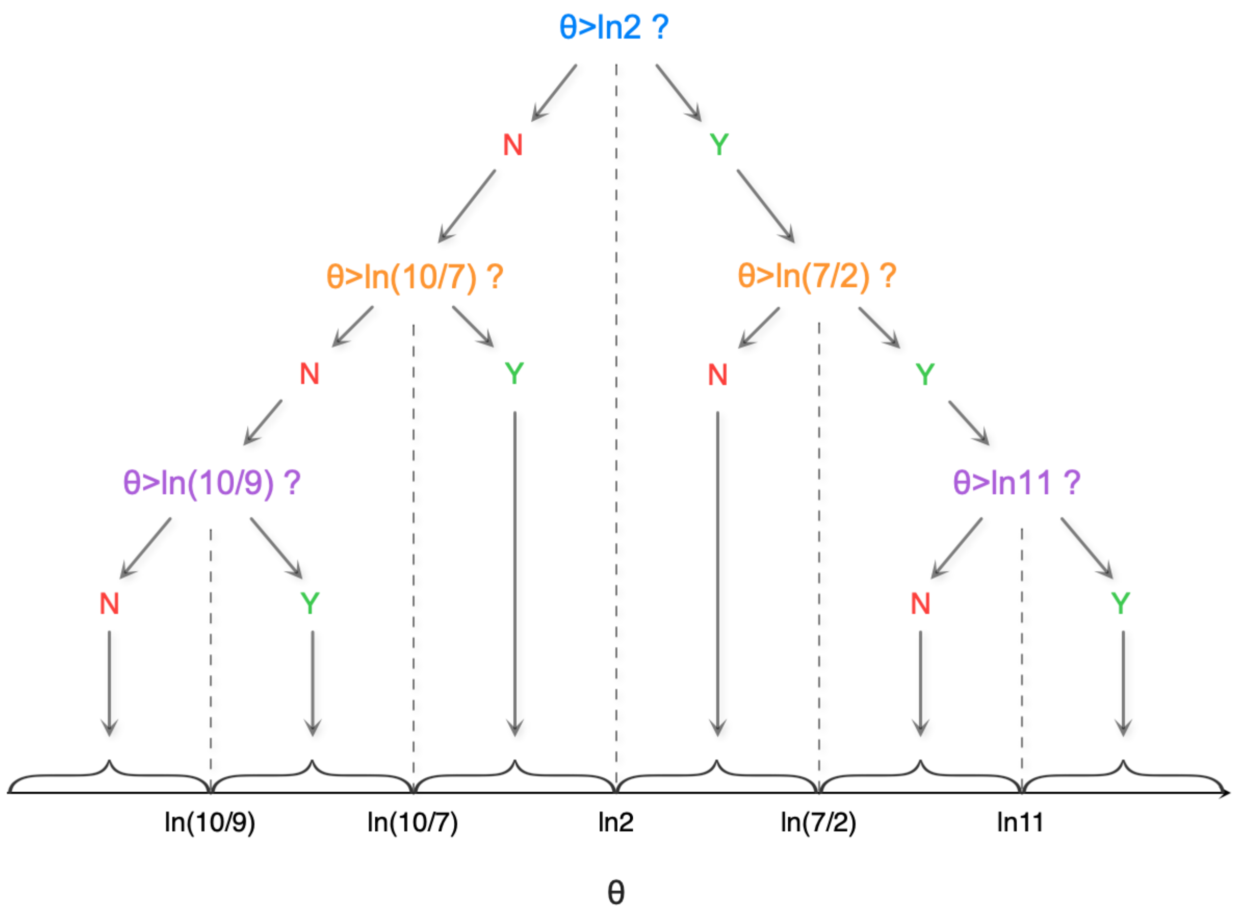


Figure 7: Unfolding Brackets

Table 6: Habit Depreciation Speed in Campbell and Cochrane (1999): Equity Premium

	Postwar Sample	Model Sample				
Habit Depreciation Factor	-	0.11	0.67	0.67	0.60	0.30
Time Discount Factor	-	0.89	0.35	0.89	0.42	0.71
Expected Excess log Return	6.69%	6.71%	44.08%	101.56%	37.44%	16.51%
Std of Excess log Return	15.20%	15.64%	31.08%	96.70%	29.62%	22.01%
Sharpe Ratio	0.43	0.43	1.42	1.05	1.26	0.75
Mean of Risk Free Rate	0.94%	0.94%	0.94%	-92.19%	0.94%	0.94%

Notes: All annualized values. Postwar (1947-95) value-weighted New York Stock Exchange stock index returns and 3-month Treasury bill rate. The third column is Campbell and Cochrane (1999) calibration. The power coefficient of the CRRA utility function is 2, as in Campbell and Cochrane (1999).

the sum of these two effects, which turns out to be making the agent in the model more risk-averse. Agents in their model, however, become so risk averse that they require such a high expected excess return that has not been observed in the history (Table 6). The time discount factor also has to be unrealistically low, 0.35 per year, in order to match the mean historical risk-free rate. When one uses a realistic annual time discount factor of 0.89, the level Campbell and Cochrane (1999) chooses, people become even more risk-averse. They require a much higher expected return and are willing to pay a hugely negative annual interest rate, -92.19%, to be able to save. The intuition is that when people care more about future, future risk matters more to them and, as a result, they become more risk-averse. The higher risk aversion drives up the motive of precautionary saving. This motive is so strong that people are willing to pay more than 90% of the principal to be able to transfer the remaining 10% of it to the next year. When one lowers the time discount factor or the habit depreciation factor, the model moments are closer to the data but the percentage differences from reality are still at least 40%, even when habit depreciates only 30% each year which is very far from the 99% HPDI of the habit depreciation factor.

Table 7 shows the effect of my estimated depreciation factor on the predictability of dividend yield on expected return. Under my estimated habit depreciation factor, the regression coefficients and R^2s are larger than post-war counterparts. It is also interesting to see that R^2s start to decrease after the second year. Figure 8 replicates Figure 9 of Campbell and Cochrane (1999), with an additional curve showing model predicted P/D under the habit depreciation factor of 0.67. Even though the fluctuations retain the same pattern, a higher depreciation speed makes P/D much lower. This is consistent with that a higher value of θ induces agents to be more risk averse and therefore to require a higher return to take on the same level of consumption risk.

It is possible that my respondents may not be representative of marginal investors who price the assets. I, however, do not need my respondents to be representative of the marginal investor in every way possible. My discussion above stands as long as the habit depreciation speed of my

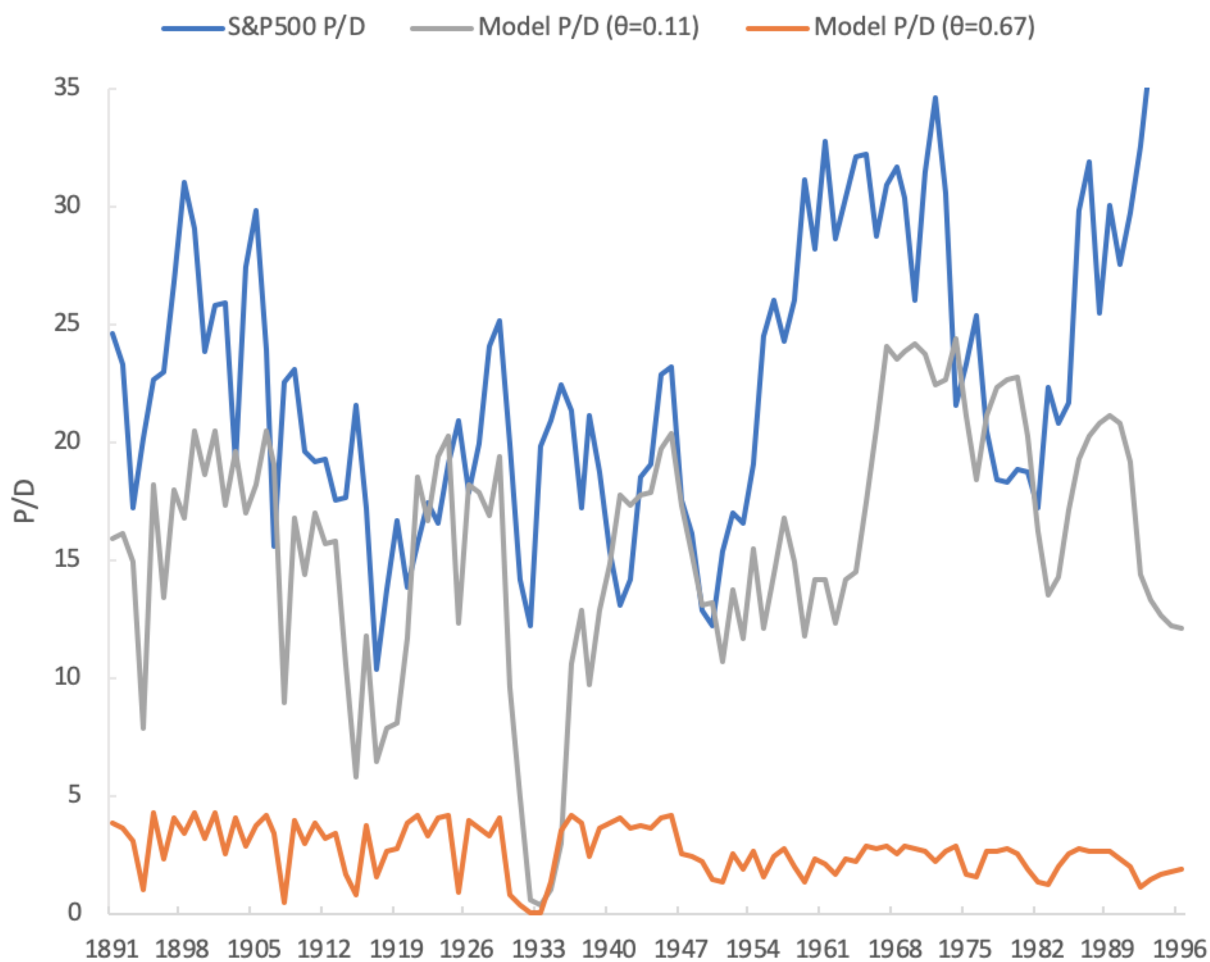


Figure 8: Historical Price/Dividend Ratio and Model Predictions Based on Consumption History

Table 7: Habit Depreciation Speed in Campbell and Cochrane (1999): Long-run Regression

	Postwar Sample		Consumption Claim ($\theta = 0.11$)		Dividend Claim ($\theta = 0.11$)		Consumption Claim ($\theta = 0.67$)		Dividend Claim ($\theta = 0.67$)	
Horizon (Years)	10 × Coefficient	R^2	10 × Coefficient	R^2	10 × Coefficient	R^2	10 × Coefficient	R^2	10 × Coefficient	R^2
1	-2.6	.18	-2.0	.13	-1.9	.08	-9.6	.60	-9.7	.53
2	-4.3	.27	-3.7	.23	-3.6	.14	-12.9	.71	-13.0	.60
3	-5.4	.37	-5.1	.32	-5.0	.19	-14.0	.67	-14.0	.56
5	-9.0	.55	-7.5	.46	-7.3	.26	-14.7	.55	-14.7	.44
7	-12.1	.65	-9.4	.55	-9.2	.30	-14.4	.44	-14.3	.34

Notes: Long-horizon regressions of log excess stock returns on the log price/dividend ratio in simulated and historical data.

respondents is same or close to that of the marginal investor, as will be the case if this parameter is a deep preference parameter that does not vary much across demographics. In section 6, I present such evidence: habit depreciation rate does not vary with age, gender, household size, and household income. One potential explanation could be that the speed that habit depreciates is determined genetically.

One of my goals for this study is to uncover the true capability of habit formation models. The literature has done a great job showing what its potential can be. What is missing is that whether habit formation is *actually* that powerful. I have found one inconsistency with reality in a popular habit formation model when I plug in my micro-based estimate of habit depreciation factor. One, however, needs to take extra caution in interpreting this inconsistency. Given that my evidence supports the existence of habit formation, it is more likely that the way habit formation is modeled needs to be improved (more on this in the following sections) than that modeling habit formation is the wrong way to go. Just like we need features beyond diminishing marginal utility, no matter how realistic and fundamental it is, to be able to better explain reality, we might also need features *in addition to* habit formation to fully explain asset pricing phenomena.

4.3 Additive and Multiplicative Habits

Additive and multiplicative habits constitute the vast majority, if not all, of habit specifications that have been taken to data. Among the two, additive habit formation is adopted relatively more often in the literature because the former can generate time-varying risk aversion while the later, at least in its simplest form, is not able to do so. Does micro evidence support this theoretical choice? I answer this question here. First, I propose four tests that distinguish these two formulations in Proposition 2 and Proposition 3.

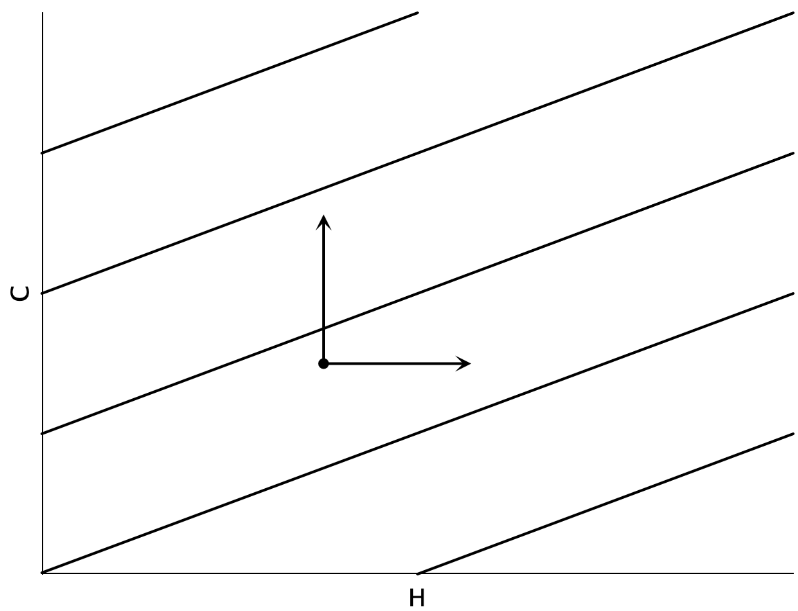


Figure 9: Additive Habit Indifference Map

Proposition 2. *Additive habit,* $u(C,H) \equiv v(C-\alpha H)$ *with* $\alpha \in \mathbb{R}^{+}$*, implies* $\frac{u_{CH}}{u_{HH}}\frac{u_H}{u_C} = 1$ *and* $\frac{u_{CH}}{u_{CC}}\frac{u_C}{u_H} = 1$.

The intuition for this set of tests is that under additive habit the indifference curves are parallel straight lines so that moving in any direction in the indifference map will not change the slope of indifference curves. The two tests are the two bases spanning all such movements: increase H alone and increase C alone (Figure 9).

Proposition 3. *Multiplicative habit,* $u(C,H) \equiv v(C/H^{\alpha})$ *with* $\alpha \in \mathbb{R}^{+}$*, implies* $\frac{Hu_H u_{CH}}{u_C u_H + Hu_C u_{HH}} = 1$*, and* $\frac{Cu_C u_{CH}}{u_C u_H + Cu_H u_{CC}} = 1$.[30]

In the space of $(\ln C, \ln H)$, the two tests of Proposition 3 have similar intuition as those for the additive habit (Figure 10).

Because the statistics for the above tests are functions of $-\frac{u_H}{u_C}$, $\frac{Hu_{HH}}{u_H}$, $\frac{u_{CH}}{u_{HH}}$, and $\frac{u_{CC}}{u_{HH}}$, I need to elicit them. Due to the generality I need in the utility function, the elicitation will be up to third-order.

$-\frac{u_H}{u_C}$ is the slope (or inverse of the slope) of indifference curve. To elicit it, I change both future and past spending in the same direction to move along an indifference curve. The resulting survey question has monthly spending graphs as in Figure 11.

[30] One can derive a class of tests based on the homotheticity of multiplicative habit. The two tests here imply this class of tests.

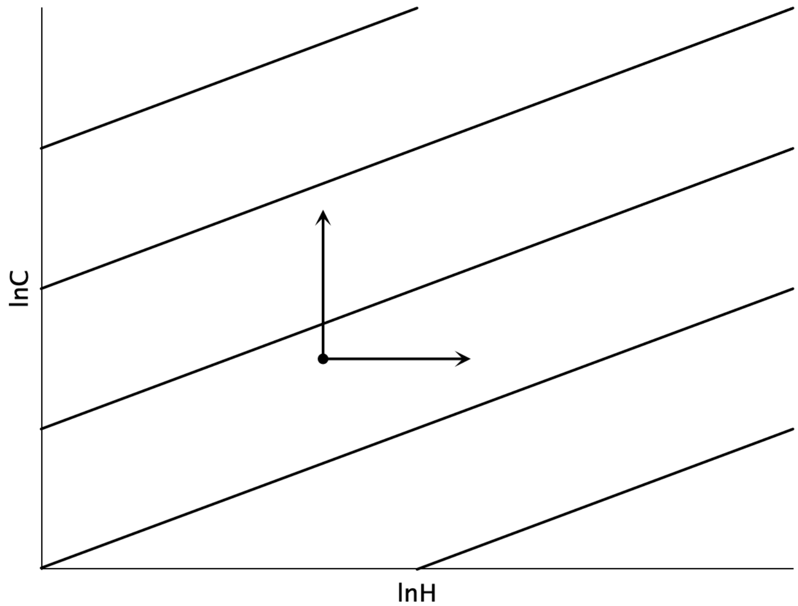


Figure 10: Multiplicative Habit Indifference Map in $(\ln C, \ln H)$ Space

Proposition 4. *Under second-order elicitation, a respondent chooses Universe One over Universe Two for a better future experience in the slope of indifference curve question if* $-\frac{u_H}{u_C} < \frac{(\rho+\theta)\Delta f}{\rho\Delta e+\theta\Delta f}$.[31]

My estimate for the slope of indifference curve is 0.62 (Table 8). The implied positive sign of u_C is consistent with my assumption that more consumption is better. The magnitude of this estimate implies that about 62% of utility gain from a higher level of consumption will gradually disappear because of habit formation. This number is remarkably close to the finding that about 60% of the effect of income on happiness are lost across time (Praag, 1971; van Praag and Frijters, 1999).

Since the habit intensity parameter, α, equals the slope of indifference curve in both additive habit (everywhere) and multiplicative habit (in steady state), my estimate of 0.62 is essentially the same as the macro estimates of about 0.6 in the literature (Havranek, Rusnák and Sokolova, 2017). Havranek, Rusnák and Sokolova (2017) also finds that the estimates using microdata tends to be lower, 0.1, than those estimated using macrodata, 0.6. It is very interesting to see that my estimate using microdata is indistinguishable from those using macrodata.

To elicit $\frac{Hu_{HH}}{u_H}$, I present the respondents with a tradeoff between past spending and fluctuation of past spending (Figure 12).

[31] $\Delta e = \$2,000$ and $\Delta f = \$200$ in the example of Figure 11. Knowledge about the time discount rate, ρ, is required to estimate slope of indifference curve and other preference parameters, the elicitation of which is relegated to section C of the appendix because of this indirect interest in it.

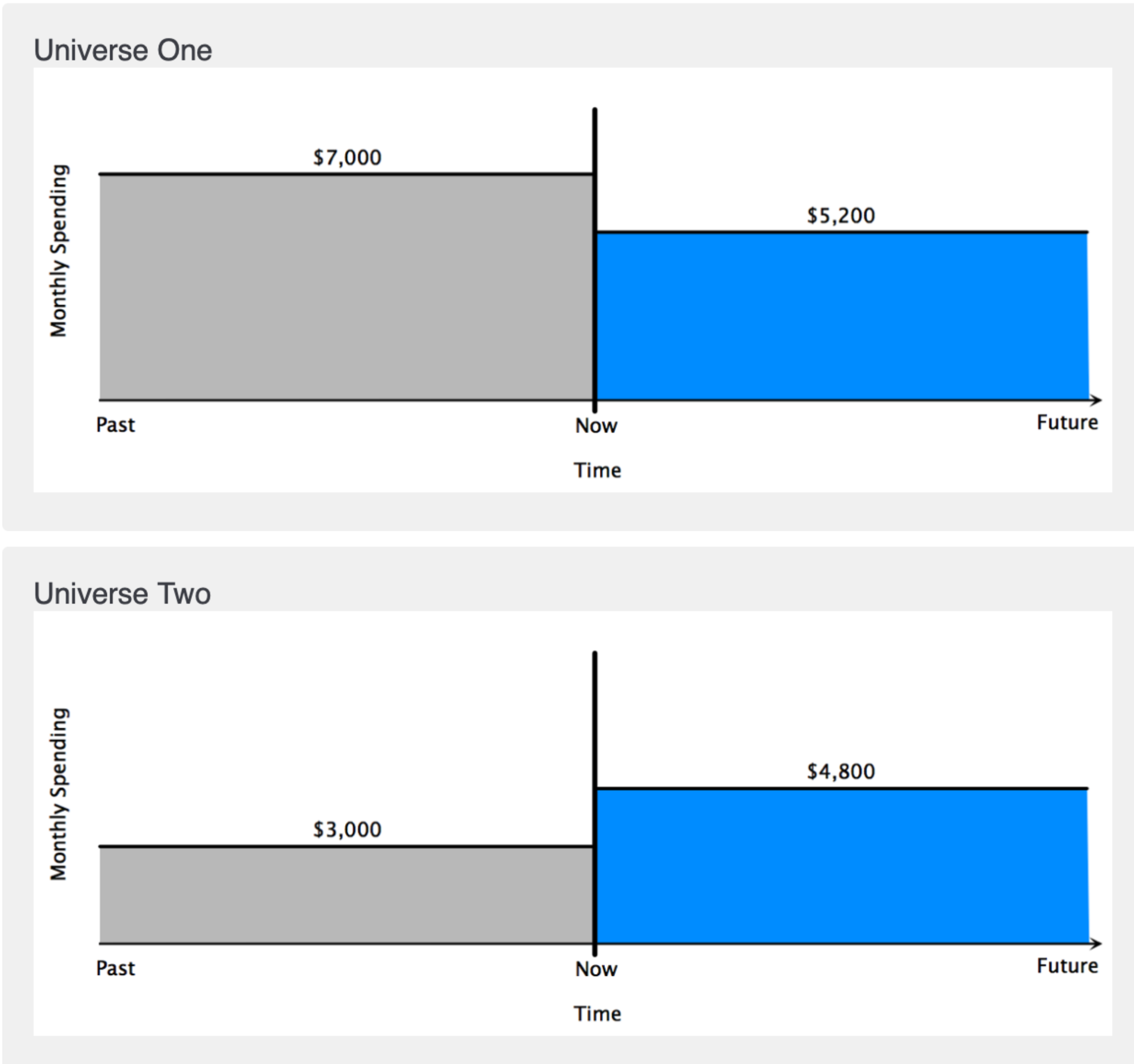


Figure 11: Monthly Spending Graphs - Slope of Indifference Curve

Table 8: Estimate of Slope of Indifference Curve

	MAP	Mean	Median	95% HPDI
$-u_H/u_C$	0.62	0.62	0.62	[0.51, 0.73]

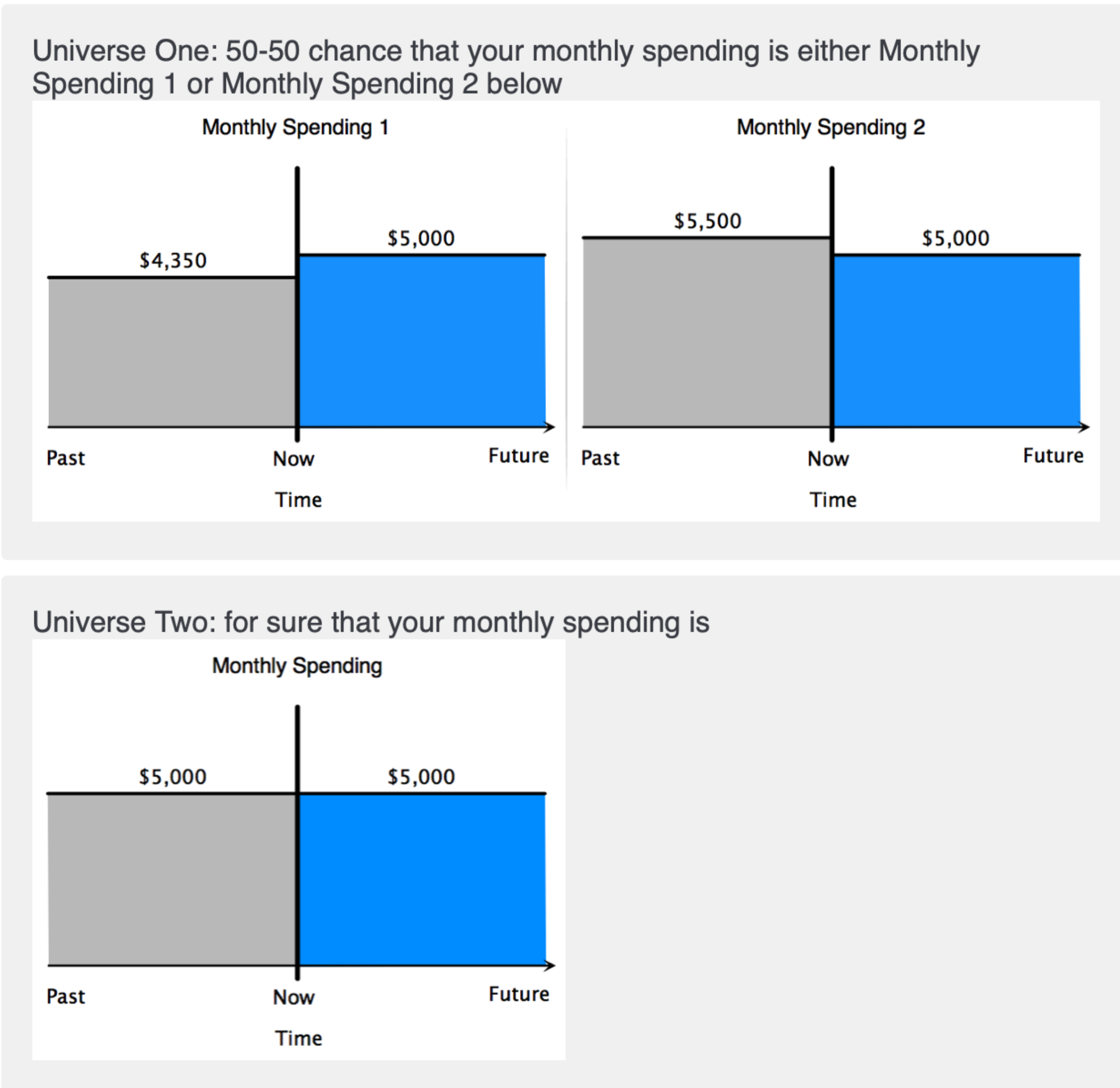


Figure 12: Monthly Spending Graphs - Hu_{HH}/u_H

Table 9: Estimate of Hu_{HH}/u_H

	MAP	Mean	Median	95% HPDI
Hu_{HH}/u_H	7.71	7.78	7.76	[6.84, 8.78]

Table 10: Estimate of u_{CH}/u_{HH}

	MAP	Mean	Median	95% HPDI
u_{CH}/u_{HH}	-0.86	-0.85	-0.86	[-1.00, -0.70]

Proposition 5. *Under second-order elicitation, a respondent chooses Universe One over Universe Two for a better future experience in the* $\frac{Hu_{HH}}{u_H}$ *question if* $\frac{Hu_{HH}}{u_H} < \frac{2(\rho+2\theta)}{\rho+\theta} \frac{\Delta f/\Delta e-1}{(\Delta f/\Delta e)^2+1} \frac{H}{\Delta e}$.[32]

I estimate $\frac{Hu_{HH}}{u_H}$ to be 7.71 (Table 9). Since I already estimated that $u_H < 0$, this implies that $u_{HH} < 0$.

The elicitation of $\frac{u_{CH}}{u_{HH}}$ rests on inducing fluctuations in both future and past spending at the same time. The monthly spending graphs for the survey question are in Figure 13.

Proposition 6. *Under third-order elicitation, a respondent chooses Universe One over Universe Two for a better future experience in the* $\frac{u_{CH}}{u_{HH}}$ *question if* $\frac{u_{CH}}{u_{HH}} < -\frac{(\rho+\theta)\Delta e+2\theta\Delta f}{2(\rho+2\theta)\Delta f}$.[33]

My estimate shows that $\frac{u_{CH}}{u_{HH}}$ is -0.86 (Table 10). Given I estimated that $u_{HH} < 0$, this tells me that $u_{CH} > 0$, which is consistent with the idea of habit formation: the higher habit is, ceteris paribus, the more valuable an additional unit of consumption is.

$\frac{u_{CC}}{u_{HH}}$ is about tradeoff between two sources of fluctuations, one from future spending and the other from past spending, which leads to the monthly spending graphs in Figure 14.

Proposition 7. *Under third-order elicitation, a respondent chooses Universe One over Universe Two for a better future experience in the* $\frac{u_{CC}}{u_{HH}}$ *question if* $\frac{u_{CC}}{u_{HH}} < \frac{\rho}{\rho+2\theta}\left(\frac{\Delta e}{\Delta f}\right)^2 - \frac{2\theta}{\rho+\theta}\frac{u_{CH}}{u_{HH}} - \frac{2\theta^2}{(\rho+\theta)(\rho+2\theta)}$.[34]

My estimate for $\frac{u_{CC}}{u_{HH}}$ is 3.72 (Table 11). This is consistent with my assumption of $u_{CC} < 0$.

With the estimates of $-\frac{u_H}{u_C}$, $\frac{Hu_{HH}}{u_H}$, $\frac{u_{CH}}{u_{HH}}$, and $\frac{u_{CC}}{u_{HH}}$, I can calculate the statistics for testing additive and multiplicative habits. The point estimates show that none of the four statistics are equal to 1 (Table 12). Actually, 1 is not even in the 99% credible intervals of these statistics. This means that my micro evidence supports neither additive nor multiplicative habit.

[32] $\Delta e = \$500$ and $\Delta f = \$650$ in the example of Figure 12.
[33] $\Delta e = \$1000$ and $\Delta f = \$200$ in the example of Figure 13.
[34] $\Delta e = \$2200$ and $\Delta f = \$500$ in the example of Figure 14.

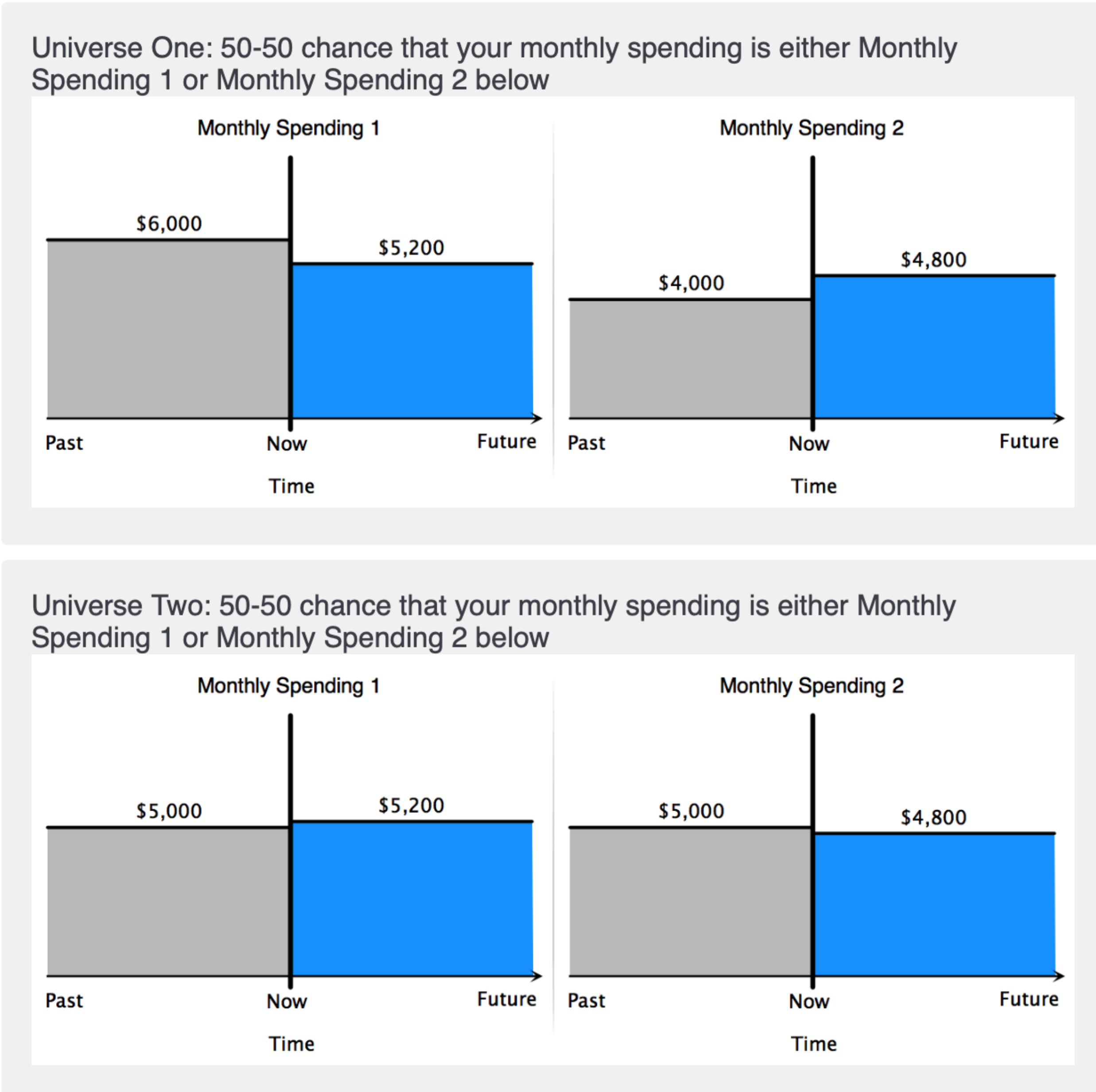


Figure 13: Monthly Spending Graphs - u_{CH}/u_{HH}

Table 11: Estimate of u_{CC}/u_{HH}

	MAP	Mean	Median	95% HPDI
u_{CC}/u_{HH}	3.72	3.72	3.72	[3.01, 4.41]

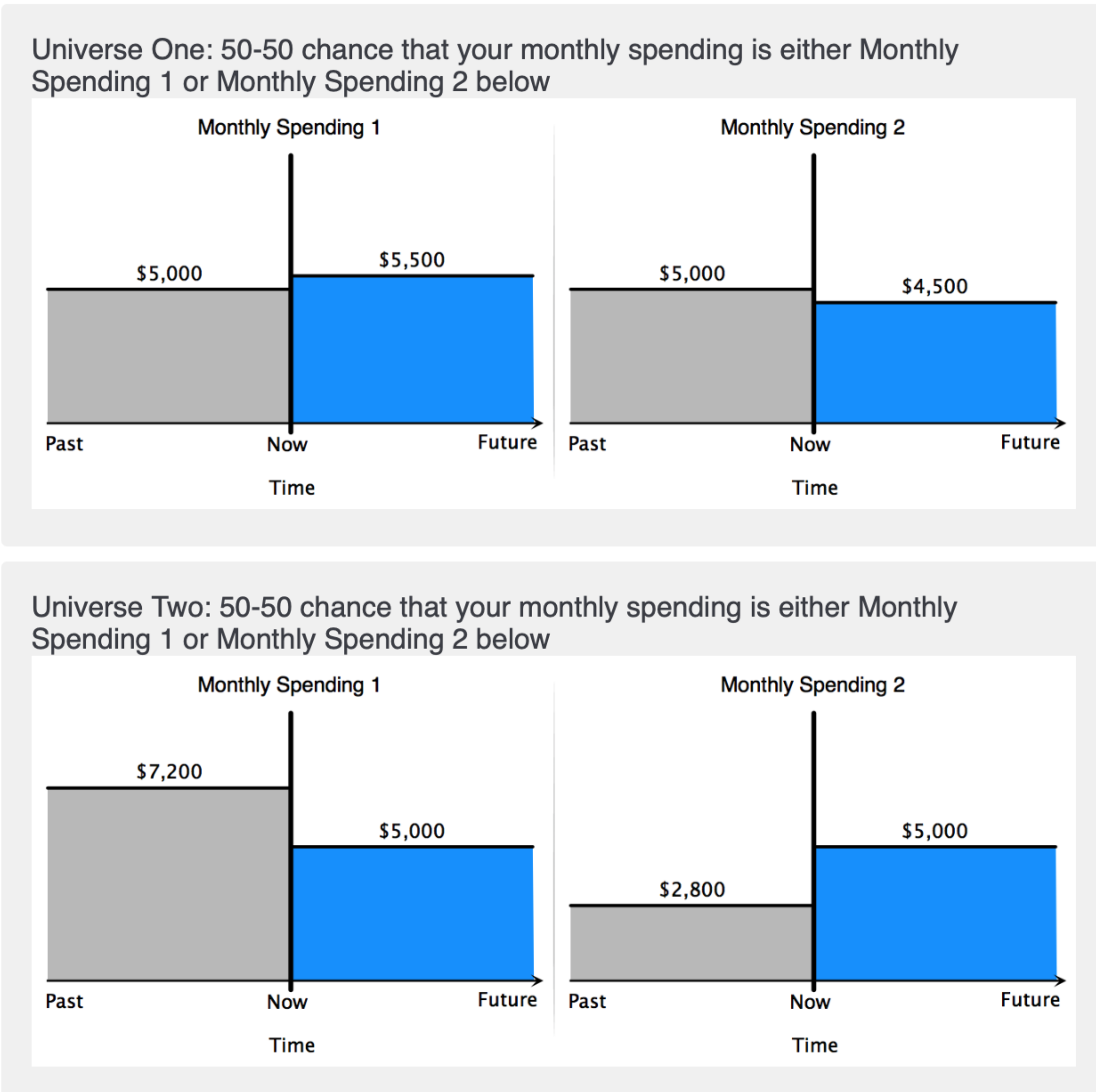


Figure 14: Monthly Spending Graphs - u_{CC}/u_{HH}

Table 12: Estimates of Test Statistics

	MAP	Mean	Median	99% HPDI
$\frac{u_{CH}u_H}{u_{HH}u_C}$	0.53	0.53	0.53	[0.36, 0.71]
$\frac{u_{CH}u_C}{u_{CC}u_H}$	0.37	0.38	0.37	[0.23, 0.56]
$\frac{Hu_H u_{CH}}{u_C(u_H+Hu_{HH})}$	0.46	0.47	0.47	[0.32, 0.63]
$\frac{Cu_C u_{CH}}{u_H(u_C+Cu_{CC})}$	-0.24	-0.25	-0.24	[-0.34, -0.16]

Given the existence of habit formation, there are two possibilities as to why this happened. On the one hand, the habit utility function is indeed of neither additive nor multiplicative form. I have yet to see a third formulation of habit utility function that has been taken to data in the literature. If a micro-consistent form exists, it might be the key to solve the inconsistency I discussed in the last section and other phenomena habit formation has difficulty explaining. On the other hand, habit itself might be insufficient. I might need to relax the representative agent assumption and/or introduce to the model other elements[35] to be able to fully match the reality. I believe the first possibility might be the near term direction for future research because my micro evidence does not exclude the possibility of a micro-consistent habit utility function.

4.4 External Habit

So far, I have been abstracting from the effect of other people's past spending on my current well-being, the external habit. This type of habit formation has been very popular in the literature, contrasting both the existing empirical evidence and our day to day intuition that the formation of habits originates mostly from my own behaviors (internal habit). These two types of habits differ in their levels of tractability and can also have dramatically different implications for optimal tax policy and welfare analysis (Lettau and Uhlig, 2000; Ljungqvist and Uhlig, 2015). In this section, I explore the question of whether others' spending indeed affects my habit.

If an increase in others' past spending, ceteris paribus, makes me worse off in the future external habit exists. That is, external habit exists if

$$Q_{EH} \equiv u\left(C, H\left(\{C\}, \{C_{others} + \Delta C_{others}\}\right)\right) - \left(C, H\left(\{C\}, \{C_{others}\}\right)\right) < 0$$

for $\Delta C_{others} > 0$, where $\{\cdot\}$ denotes historical path and I explicitly allow the dependence of habit on other people's past spending C_{others}.

To elicit the sign of Q_{EH} and the mixture coefficient (see below), I use a set of questions where both others' and my past spending vary. This leads to the monthly spending graphs in Figure 15 and the elicitation in Proposition 8.

[35]For example, inattention (Sims 1998, 2003; Auclert, Rognlie and Straub in preparation).

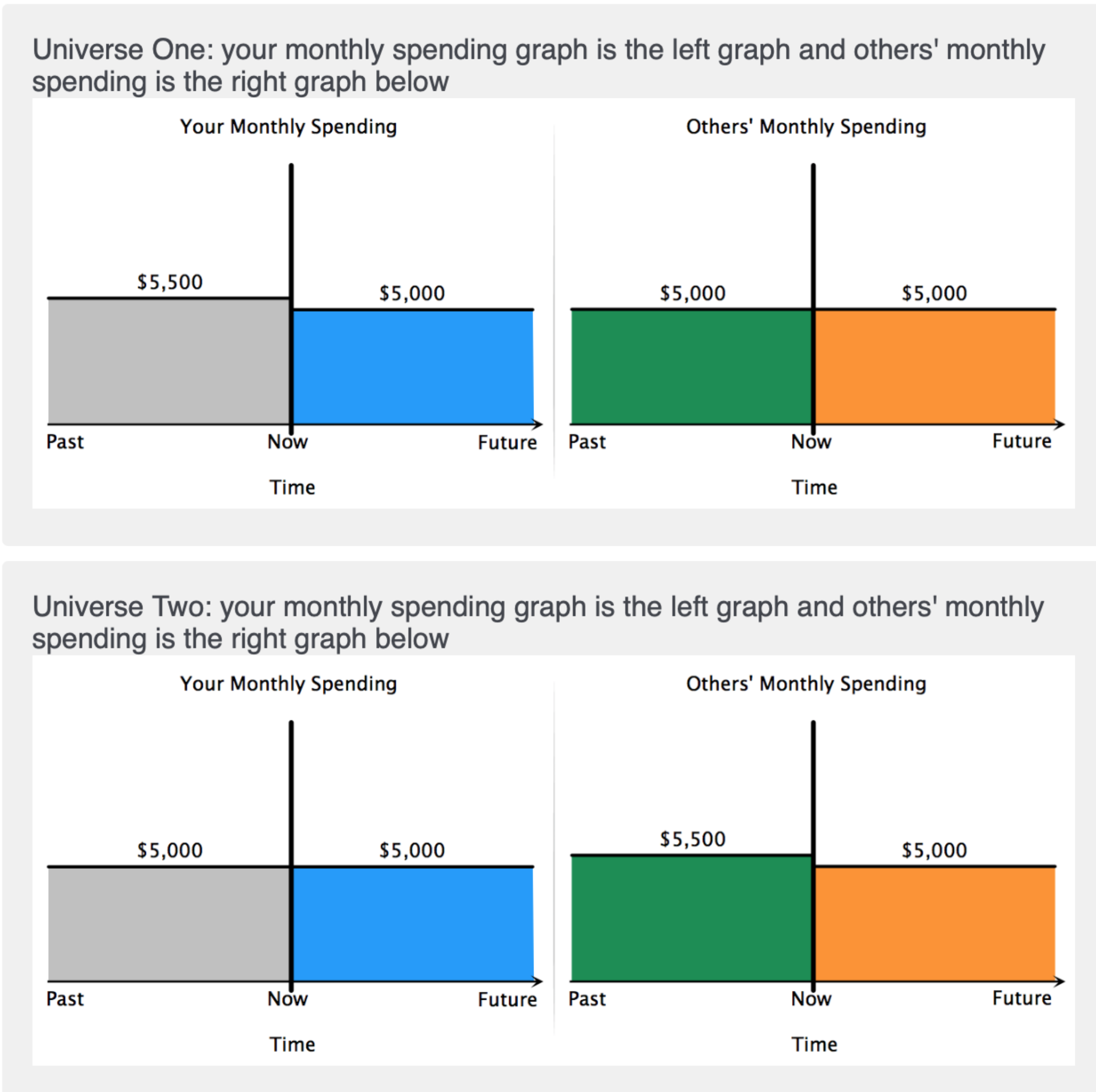


Figure 15: Monthly Spending Graphs - External Habit

Table 13: Response Frequency (Percentage) for External Habit Question

$\text{sgn}(Q_{EH})$	-1	-1, 0, or 1
First Wave	54	46
Second Wave	54	46

Table 14: Estimate of Existence of External Habit

	MAP	Mean	Median	90% HPMI	95% HPMI	99% HPMI
$\text{sgn}(Q_{EH})$ (strict)	-1.00	-0.84	-1.00	[-1.00, -1.00]	[-1.00, 1.00]	[-1.00, 1.00]
$\text{sgn}(Q_{EH})$ (lenient)	-1.00	-1.00	-1.00	[-1.00, -1.00]	[-1.00, -1.00]	[-1.00, -1.00]

Proposition 8. *Given the existence of internal habit, a respondent chooses Universe One over Universe Two for a better future experience in the external habit question if external habit exists.*

The reverse of Proposition 8 does not hold: choosing Universe Two over Universe One does not necessarily imply the nonexistence of external habit. As long as external habit is weak enough relative to internal habit, a respondent would always prefer Universe Two for a better future experience. My survey does not contain information that allows me to separate the different possibilities for the sign of Q_{EH} under the scenario of always choosing Universe Two. Therefore, I check each possibility. If always choosing Universe Two means $Q_{EH} < 0$ (most lenient), all my response implies the existence of external habit. If always choosing Universe Two means $Q_{EH} > 0$ (strict) when always choosing Universe Two, I am least likely to find evidence for external habit, while if $Q_{EH} = 0$ (lenient) I am relatively more likely to find external habit.

The response frequency in Table 13 indicates that the choice of the average respondent agrees with the existence of external habit. My estimate under the strict case shows that $Q_{EH} < 0$ in at least 90% HPDI while the opposite sign could emerge in 95% or higher-level HPDI (Table 14). The lenient scenario, however, finds evidence of a negative sign for the utility difference even at 99% HPDI. Overall, external habit exists at least at the 90% level.

Composition of Internal and External Habits

Given that I have found evidence for both internal and external habits, what is their relative importance? To provide an answer to this and later questions, I augment the habit model in ways enabling me to answer these questions. It is worth emphasizing that the augmentation of the model does not invalidate previous results because the augmented model nests the unaugmented model. Equivalently, one can think of my habit model as the most expanded version including everything that has been and will be discussed. I just did not show some of the variables in previous sections because either they were constant or cancels in elicitation so not explicitly listing them results in no loss of generality.

Table 15: Estimate of External Habit Mixture Coefficient

	MAP	Mean	Median	95% HPDI
ω	0.17	0.16	0.16	[0.07, 0.26]

I have already implicitly augmented the model in the first part of this section where I allow habit to depend on other people's spending. In this section, I specify this dependence à la Grishchenko (2010):

$$\dot{H} = \theta\left((1-\omega)C + \omega C_{others} - H\right) \tag{1}$$

where ω is the external habit mixture coefficient governing the contribution of others' spending (C_{others}) on my habit. To elicit this parameter, I can use the same question that elicits the existence of external habit in the last section.

Proposition 9. *Under exact elicitation, a respondent chooses Universe One over Universe Two for a better future experience in the external habit question if* $\omega > \frac{\Delta C}{\Delta C + \Delta C_{others}}$.[36]

The point estimate indicates others' spending contributes to about 17% of my habit (Table 15). The 95% HPDI of the mixture coefficient does not include 0 which is consistent with the existence of external habit, as shown above.

4.5 Relative Strength of Habit Formation and Keeping Up with the Joneses

To elicit the relative strength of habit formation and keeping up with the Joneses, unhide others' spending in the utility function, $u(C, H, C_{others})$. Then, I elicit the ratio of $\frac{u_{C_{others}}}{u_H}$ by varying others' spending in both the past and the future. The survey question has the monthly spending graphs in Figure 16.

Proposition 10. *Under first-order elicitation, a respondent chooses Universe One over Universe Two for a better future experience in the* $\frac{u_{C_{others}}}{u_H}$ *question if* $\frac{u_{C_{others}}}{u_H} < \frac{\omega}{\rho+\theta}\left(\rho\frac{\Delta C^{U2}_{others}}{\Delta C^{U1}_{others}} - \theta\right)$.[37]

My point estimate for $\frac{u_{C_{others}}}{u_H}$ is about 1.05 (Table 16) and not significantly different from 1 at the 5% level. This supports that habit formation has about the same effect on utility as keeping up with the Joneses.

I draw two additional implications based on the significant negative sign of $u_{C_{others}}$ as implied from the estimate. First, keeping up with the Joneses exists separately from external habit. In the elicitation, external habit and keeping up with the Joneses are calculated separately. The fact that the estimate of $u_{C_{others}}$ is significantly negative means keeping up with the Joneses exists after

[36] $\Delta C = \$500$ and $\Delta C_{others} = \$500$ in the example of Figure 15.
[37] $\Delta C^{U1}_{others} = \$300$ and $\Delta C^{U2}_{others} = \$3,000$ in the example of Figure 16.

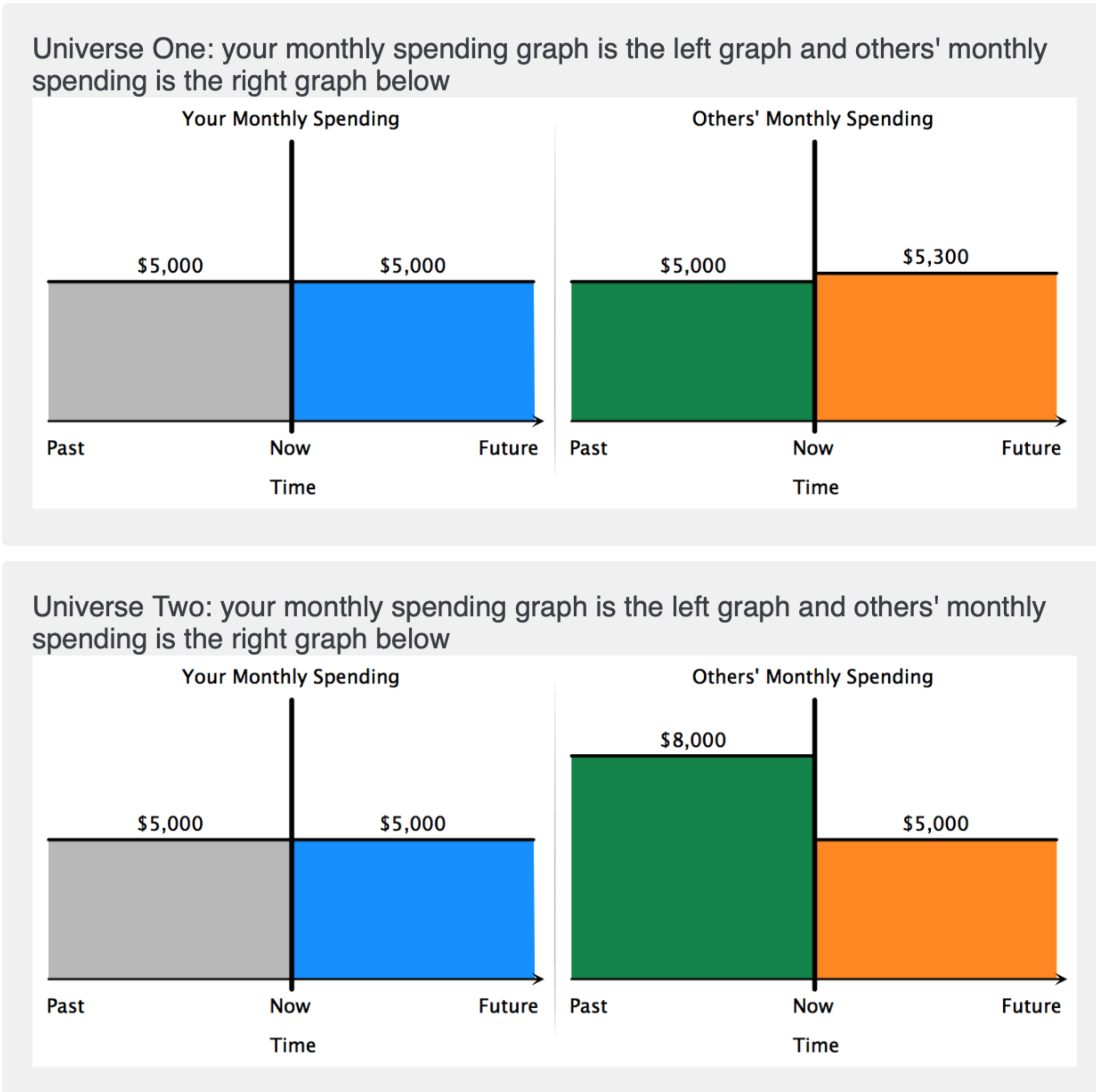


Figure 16: Monthly Spending Graphs - $u_{C_{others}}/u_H$

Table 16: Estimates for $u_{C_{others}}/u_H$

	MAP	Mean	Median	95% HPDI
$\frac{u_{C_{others}}}{u_H}$	1.05	1.06	1.06	[0.70, 1.41]

controlling for external habit. Second, keeping up with the Joneses is stronger than altruism. I did not restrict the sign of $u_{C_{others}}$ a priori, which can go both ways: altruism ($u_{C_{others}} > 0$) and keeping up with the Joneses $u_{C_{others}} < 0$. Essentially $u_{C_{others}}$ represents the net effect of these two phenomena. The significant negative sign of $u_{C_{others}}$ therefore indicates keeping up with Joneses dominates altruism.

5 Explaining Easterlin Paradox

After nearly five decades of discussion, the income-happiness paradox proposed by Easterlin distills to the question that why income and happiness tends to be not associated in the long-run while positively associated in the short-run and cross-section (Easterlin, 1973, 1974; Stevenson and Wolfers, 2008; Sacks, Stevenson and Wolfers, 2012; Easterlin, 2017; Kaiser and Vendrik, 2018). Keeping up with the Joneses and habit formation have been proposed as potential explanations of this puzzle (Easterlin, 1973, 1974, 1995; Clark, Frijters and Shields, 2008). Recent evidence shows that keeping up with the Joneses alone cannot explain this phenomenon (Luttmer, 2005; Lewbel et al., 2018; De Giorgi, Frederiksen and Pistaferri, 2019). Using my estimates on keeping up with the Joneses and habit formation of both the internal and external types, I show in this section that while each alone cannot, joining forces they can generate the patterns of income and happiness of the Easterlin Paradox.

Four clarifications merit discussion before proceeding. The first is that I will focus on the causal channel that income changes happiness. Our typical life experiences and studies exploiting exogenous variations support income causing happiness to change (Frijters, Haisken-DeNew and Shields, 2004; Gardner and Oswald, 2007). Evidence aside, this causality motivated the discovery of the paradox[38] and is the most counter-intuitive, interesting,[39] and policy-relevant. Non-income happiness-altering factors do not help with the explanation of the paradox because they generally improve with income, making the long-run income-happiness relationship even more mysterious (Di Tella and MacCulloch, 2008). The second clarification is that following the literature (Clark, Frijters and Shields, 2008; Benjamin et al., 2012; Perez-Truglia, 2019), I assume the potential distinction between happiness and utility is of minimal effects on my discussion below. Third,

[38] One can take a peek at the question that interested Easterlin from the titles of his seminal papers: “Does Money Buy Happiness?”(Easterlin, 1973) and “Does Economic Growth Improve the Human Lot? Some Empirical Evidence”(Easterlin, 1974).

[39] This is evidenced by the vast majority of the speculated explanations of the paradox has focused on this channel.

the paradox holds when I replace income with consumption[40]: consumption moves closely with income (Figure 17) while happiness still has a long-term trend of about zero (Figure 18). The relative lack of attention to the relationship between consumption and happiness is at least partly due to a lack of reliable individual-level data on consumption. Compared to income, consumption relates more directly to human welfare, as is widely accepted in the economics literature. Fourth, there are at least three measures of happiness in the literature, of which affect measures feelings of recent days, life satisfaction evaluation of life as a whole, and eudaemonia personal growth and meaning. I will focus on the first two because their measurements are the most reliably measured (OECD, 2013), studied, and relevant for the paradox. I will use the instantaneous utility as a proxy for affect[41] and lifetime utility for life satisfaction.

To see how habit formation and keeping up with the Joneses resolve the paradox, let me focus on a simplified environment that accentuates the mechanisms reconciling tensions of the paradox. I specify that people's utility is affected by both internal and external habits as well as keeping up with the Joneses. Habit evolves according to equation (1) with the habit depreciation rate and the external habit mixture coefficient calibrated to my estimates, 1.11 and 0.17 respectively. Keeping up with the Joneses and external habit emerge after the agent realizes that other people's consumption has changed, which is assumed to be k years after the consumption change happens.[42] With no loss of generality, I assume the full effect of keeping up with the Joneses applies instantly once others' spending changes become known to the agent.

The effects of habit formation and keeping up with the Joneses on utility, to a first-order approximation, is captured by u_H/u_C and $u_{C_{others}}/u_C$. My estimates of them are both less than negative one at the 95% level, which means, contrary to common beliefs, each of them alone cannot fully explain the paradox. The long-run zero income-happiness slope dictates that

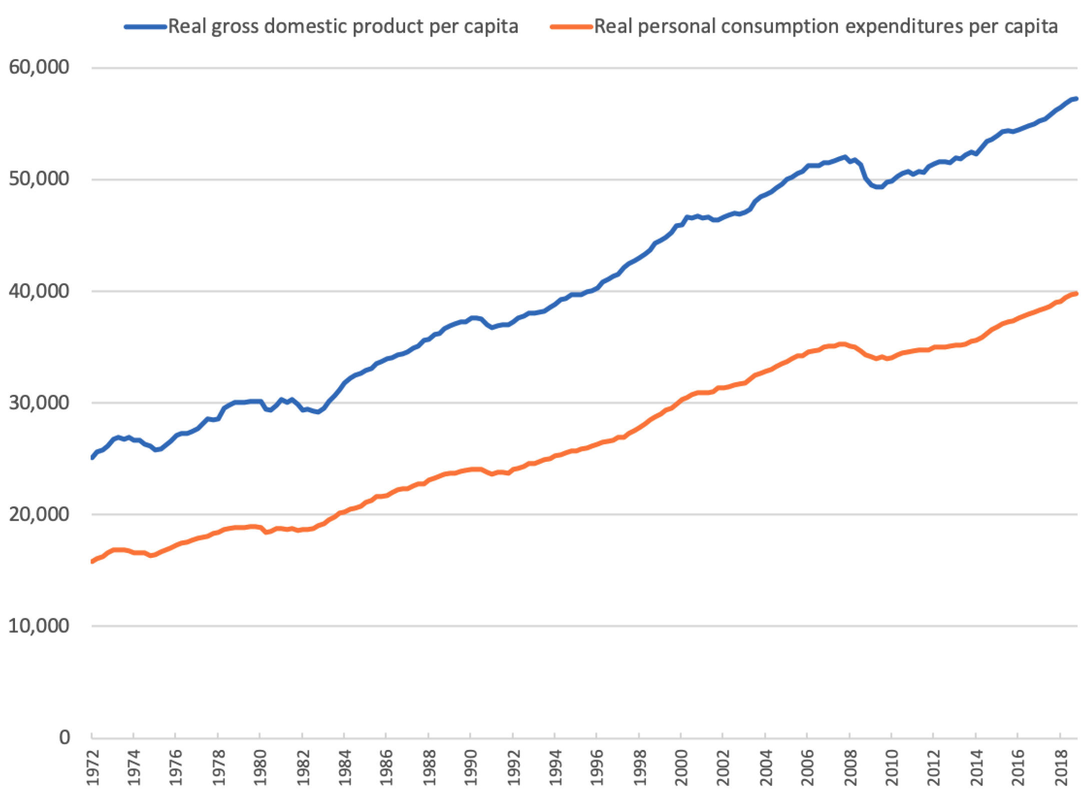
$$\frac{u_H}{u_C} + \frac{u_{C_{others}}}{u_C} = -1 \tag{2}$$

, which my estimates support at the 95% level (Table 17). The point estimate of the left-hand side is less than negative one, which, aside from statistical precision considerations, provides the potential for my resolution to be consistent with the improvement of happiness-altering non-income factors (Di Tella and MacCulloch, 2008) and with the slightly negative long-run income-happiness slope in the U.S. (Stevenson and Wolfers, 2008; Firebaugh and Tach, 2012). Since my interest here is the link between income and happiness applicable not solely to the U.S., let me focus on the case where they sum to negative one. For illustrative purposes, I choose $u_H/u_C = -0.55$ and

[40] Throughout, consumption refers to real consumption.

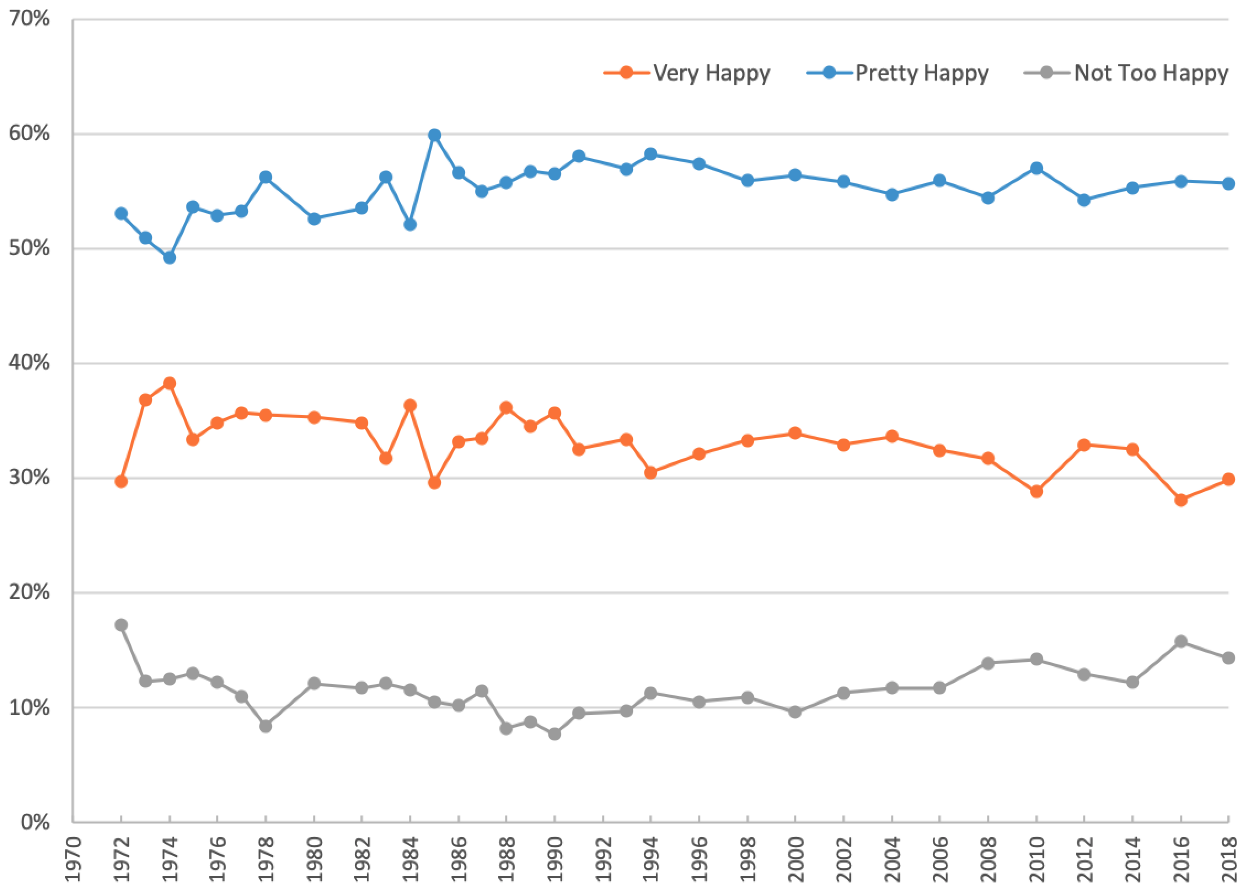
[41] One can alternatively use the integral of instantaneous utility over the past one day or week as proxies for affect, which are the typical time frames for survey questions on affect. I tried both and also other time frames and find that the difference is trivial. This is a necessary implication of the fact that the curvature of the instantaneous utility is rather smooth (see below).

[42] The exact time of the delay does not matter for the resolution of the paradox. It only affects how fast people's utility converges to its steady state.



Notes: Chained 2012 dollars. Dara from U.S. Bureau of Economic Analysis.

Figure 17: Real GDP and PCE Per Capita in the U.S., 1972 - 2018



Notes: Survey response from the survey question: "Taken all together, how would you say things are these days–would you say that you are very happy, pretty happy, or not too happy?" Data from General Social Surveys.

Figure 18: General Happiness in the U.S., 1972 - 2018

Table 17: Estimates for the Easterlin Paradox

	MAP	Mean	Median	95% HPDI
$\frac{u_{C_{others}}}{u_C}$	-0.65	-0.65	-0.65	[-0.90, -0.41]
$\frac{u_H}{u_C}+\frac{u_{C_{others}}}{u_C}$	-1.26	-1.27	-1.27	[-1.60, -0.97]

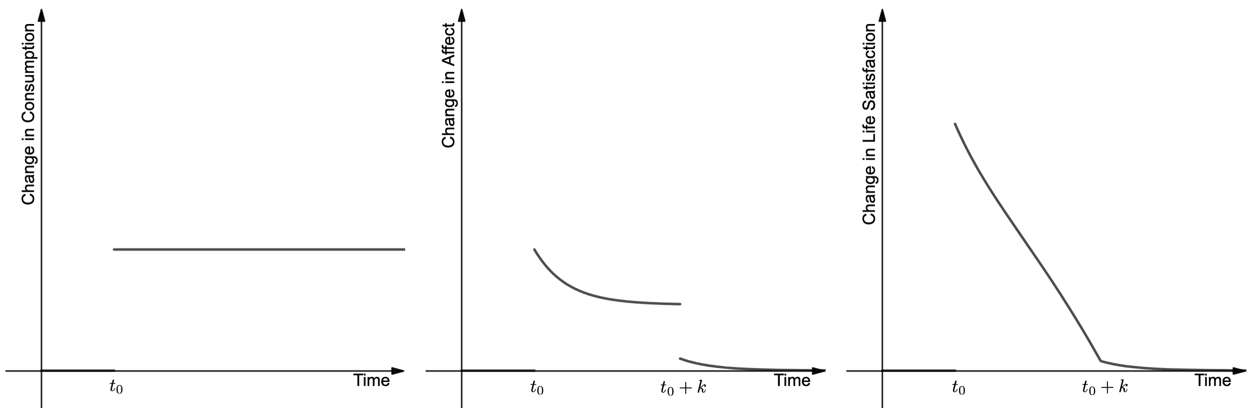
$u_{C_{others}}/u_C = -0.45$, both of which are within their respective 95% HPDIs. As long as they sum to negative one, the exact values of the two ratios only slightly affect the steady-state level of happiness and the convergence speed to steady states, both of which do not alter the income-happiness pattern that is what the Easterlin paradox is all about.

The intuition of equation (2) is that, to a first order approximation, habit formation and keeping up with the Joneses entirely cancel the happiness effect of consumption changes in the long-run. To see this, suppose a single-episode-growth scenario where the economy was at some steady state such that its residents were at some constant level of happiness before the instant t_0. Imagine that the economy grows at t_0 so that everyone's consumption permanently increases by a small amount of Δc for all instants starting from t_0 onwards (Figure 19a). As a result, to a first-order approximation,[43] the agent's affect goes up by $u_C \Delta c$ at t_0. As time passes, people get used to this higher level of consumption, resulting in the buildup of internal habit that pulls affect down (Figure 19b). At the instant before keeping up with the Joneses kicks in, t_0+k, the remaining effect of the higher consumption on happiness is lowered to $\left[u_C+(1-\omega)\left(1-e^{-\theta k}\right)u_H\right]\Delta c$. At t_0+k, the agent realizes that everyone else also enjoys the same higher level of consumption as she enjoys and feels worse as a result of social comparison–keeping up with the Joneses–which further pushes the gain of affect down to $\left[u_C+(1-\omega)\left(1-e^{-\theta k}\right)u_H+u_{C_{others}}\right]\Delta c$. After that, external habit joins the play and, together with internal habit, gradually wears off the remaining gain of affect until it completely disappears.

Integrating the affect discounted by time preference,[44] I get the changes to life satisfaction (Figure 19c), the second measure of happiness. From the behavior of affect as analyzed above, it should come at no surprise that life satisfaction first increases then gradually decreases to its previous level. For later reference, let me call this wear-off effect: over time, habit formation and keeping up with the Joneses cancel out the happiness brought by a permanently higher level of consumption or income. Under the influence of this effect, at distant future instants, the agent feels as if the change to consumption did not happen even though her consumption is permanently higher. It is worth noting that before the wear-off effect reaches its full potency, the higher consumption

[43]Throughout my analysis in this section, I will limit my attention to first-order approximations, as there is no point going beyond it when parameter value of $u_{C_{others}}/u_C$ is chosen based on its first-order elicitation. This is a good approximation when the change Δc is small which I assume here.

[44]I calibrate the time discount rate to 0.15, based on my estimate of this parameter. See section C of the appendix for details.



(a) Change in Consumption (b) Change in Affect (c) Change in Life Satisfaction

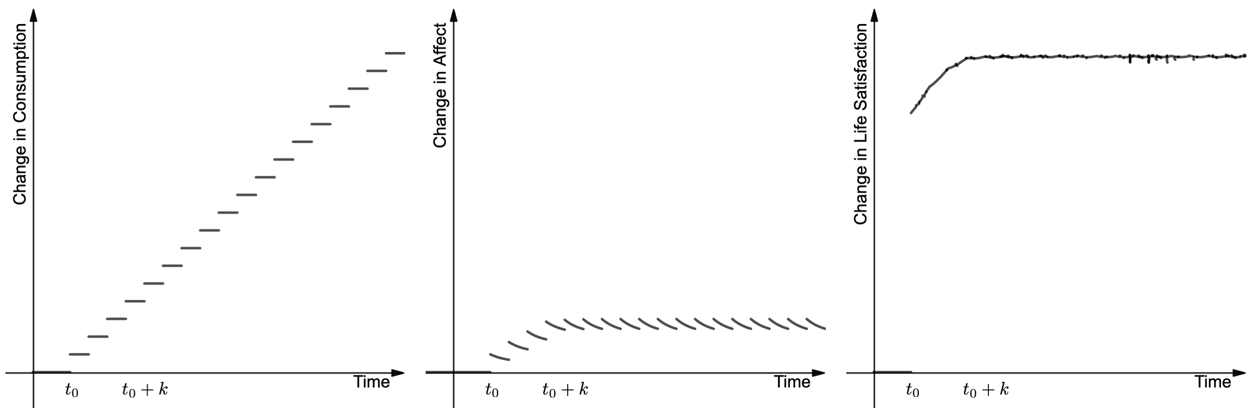
Figure 19: One-Episode Growth

indeed brings higher levels of happiness. Wear-off effect reveals the key intuition of how habit formation and keeping up with the Joneses resolve the income-happiness paradox: the agent feels happier in the short-run after the consumption increase, but in the long-run this excitement fades away.

In reality, economies tend to grow over time and, as a result, people typically earn more and consume more over time. To capture the key aspect of this phenomenon, suppose everyone increases her consumption permanently by Δc every one year after t_0 (Figure 20a). Figures 20b and 20c plot the changes to the agent's happiness as time progresses. There should be of no surprise that habit formation wears off the gain of happiness within each year as in the one-episode-growth scenario above.[45] What is new is the trend of happiness, which gradually builds up and plateaus. Again, for later reference, let me label these two phenomena about the trend transition effect and plateau effect. The transition effect exists, contrasting the decreasing trend as in the one-episode-growth scenario, because the growing consumption brings in each year an episode of wear-off effect whose initial happiness-enhancing phase[46] stacks onto that from previous year. As habit formation and keeping up with the Joneses take effect, the happiness-reducing momentum gradually builds up and eventually cancels the happiness-enhancing momentum leading us to the happiness plateau, which happens at the moment exactly when the wear-off effect brought by the consumption increase at t_0 is in full swing.

[45]The discontinuities of the utility changes at the start of each year after t_0 are purely out of the simplifying assumption that consumption permanently increase at start of each year after t_0, which is not essential. One can imagine after an income increase, one increases consumption slowly, e.g. due to habit formation, so that the jumps to the utility changes disappears. All my analysis remain unchanged under this scenario. Here I do not employ this to highlight the wear-off effect of habit formation.

[46]The time interval when happiness increases after t_0 in Figures 19b and 19c.



(a) Change in Consumption (b) Change in Affect (c) Change in Life Satisfaction

Figure 20: Multi-Episode Growth

Because the wear-off effect on happiness are proportional to Δc,[47] the transition and plateau effects on happiness are also proportional to Δc (Figure 21). Let me call this level effect: higher consumption growth leads to higher levels of happiness during both the transition and plateau phases.

The level effect explains the cross-sectional positive correlation between income and happiness. Richer people or countries enjoy higher consumption and therefore are on higher happiness curves, which implies that they are happier compared to poorer people or countries on the lower happiness curves.[48] Constant economic fluctuations in reality make consumption fluctuate, putting the agent frequently into transition phases. The transition effect, therefore, explains the short-run positive correlation between income and happiness. It is worth noting that regardless of income (or consumption) increase or decrease, transition effect always implies a positive relationship between income and happiness. Faster growing economies, like developing countries, tend to enjoy faster economic growth, which by the level effect, leads to larger increases in happiness during the transition phase, as is observed in reality (Frijters, Haisken-DeNew and Shields, 2004). The plateau effect explains the long-run nil correlation between income and happiness. Even though income constantly fluctuates, it fluctuates around its trend. This trend growth determines the plateau

[47] Because my analysis here focuses on first-order approximations. To the extend that people's marginal utility of consumption is always positive, the analysis still holds: even though utility effect of the difference of high and low consumption changes will be smaller, difference remains positive.

[48] My above analysis has assumed a representative agent, purely to isolate the key mechanisms for resolving the paradox from potential complications implied in heterogeneities of the reference groups for social comparison. The analysis carries through with reasonable specifications of the reference groups. For example, one can assume that the income of the reference group changes by the same amount as the (heterogeneous) agent's income does. Note also that the level effect remains if everyone in the economy gets proportionally richer, implying that rising income inequality is not a requisite for resolving paradox with the help of habit formation as is suspected in the literature (Clark, 2016).

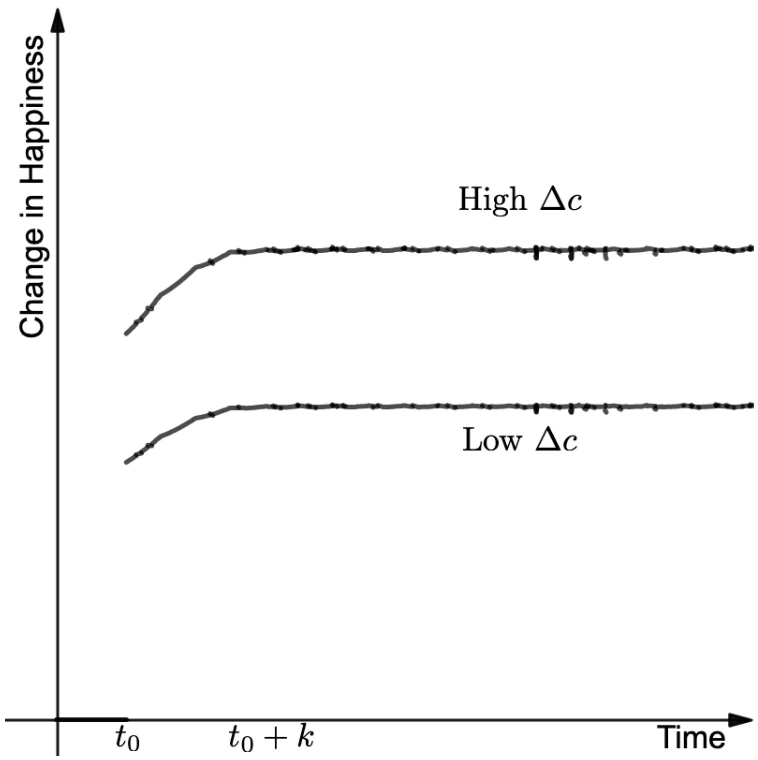


Figure 21: Level Effect

Table 18: Two Paradoxes

Time Frame	Easterlin Paradox	Escalator Paradox	Explanation
Long-run	Why getting more *income* doesn't raise **happiness**?	Why running more *stairs* doesn't raise **elevation**?	Plateau effect
Short-run	Why getting more *income* raises **happiness**?	Why running more *stairs* raises **elevation**?	Transition effect (+ fluctuation)
Cross-section	Why *richer* people/countries are **happier**?	Why *faster* people are **more elevated**?	Level effect

level of happiness, which pins down the long-run trend of happiness. To put it another way, in the long-run, the trend of the happiness curve flattens even though consumption and income constantly grow, hence the nil correlation.

To deepen the intuition, let me draw an analogy. Imagine you are about to run with a uniform speed Δc stairs per unit of time against a down escalator. The escalator is initially still and will gradually accelerate to the speed after you step onto it,

$$\frac{u_H + u_{C_{others}}}{u_C}\Delta c = -\Delta c$$

. Suppose the escalator is long enough so that it will catch up to your speed before you reach the other end of it. Your elevation represents happiness. The total stairs you run is the level of consumption, which implies that the speed you run, Δc stairs per unit of time, equals to the consumption growth rate per unit of time. The escalator concretize the joint effect of habit formation and keeping up with the Joneses. With this analogy, allow me to propose and resolve another paradox, the Escalator paradox, which parallels the Easterlin paradox (Table 18). The Escalator (Easterlin) paradox states that running more stairs (getting more income) raises elevation (happiness) in the cross section and short-run but not so in the long-run. Why this is the case? For the long-run scenario, the escalator (habit formation and keeping up with the Joneses) eventually catches up to your running speed (consumption growth) after which the additional stairs you run (additional consumption you enjoy) will not affect the your elevation (happiness). In the short-run, you gain elevation (happiness) because your running speed (consumption growth) is faster than that of the escalator (cancelling effect of habit formation and keeping up with the Joneses). In the cross section, people who run faster (people or country that are richer) will be more elevated (happier) because the absolute difference between your speed (consumption growth) and the speed of the escalator (cancelling effect of habit formation and keeping up with the Joneses) will be larger.

How does the above analysis speak to the questions that motivated the paradox: does money buy happiness (Easterlin, 1973), and does economic growth improve human lot (Easterlin, 1974)? To phrase the questions in a slightly more accurate way, should we promote economic growth if happiness eventually will stop growing with economic growth? The answer is yes. Happiness would decrease if the economy shrinks or grows at slower speeds. In other words, economic growth initially drives up happiness and eventually *maintains* it. If the economy grows slower or even shrinks, the resulting slower consumption growth will cause happiness to drop. Even though habit formation and keeping up with the Joneses will eventually bring it up a little bit, happiness will plateau at a level lower than the level it would plateau had the economy not slowed down.

6 Discussion and Robustness

In this section, I discuss the robustness of my results to departures from some assumptions underlying above results.

6.1 Demographic Heterogeneity

I collected information on age, gender, household size, and household income of my respondents. It is interesting to see how my estimates are correlated with the demographics. I modify the statistical model to allow the demographic variables to shift the means of the parameter distributions and rerun my estimation. I find that the demographics do not affect my estimates (Table 19). In particular, 0 is included in all of the 95% HPDIs except that of the effect of household income on $\frac{Hu_{HH}}{u_H}$. After accounting for multiple hypothesis testing, this effect vanishes.[49]

This result supports the view that the parameters I elicited are deep preference parameters that do not vary with sociodemographic characteristics. Since the ratios of utility derivatives are dependent on the spending profiles, the fact that the estimates do not vary with demographics of the respondents and therefore heterogeneous spending profiles in reality is reassuring, for it implies that my respondents understood the hypothetical situations of the survey and were able to answer the survey questions without letting their own demographic situations confound their responses.

6.2 Finite Horizon

I assume infinite horizon in my habit model, as do almost all current habit formation models in the literature. To investigate the effect of this assumption, I re-derive all my elicitations of the preference parameters under finite horizon, resulting in minimal changes: there is no change for the elicitations of some parameters while some tiny changes for others.[50] I rerun my estimation

[49]The adjusted p-value under Holm algorithm for this effect is 0.39.

[50]The thresholds for the habit depreciate rate and external habit mixture coefficient are exactly the same under both time horizons. The changes to the thresholds of other parameters are simply replacing 1 by $1-e^{-\rho T}$ or $1-e^{-(\rho+\theta)T}$ or $1-e^{-(\rho+2\theta)T}$, all of which are close or very close to 1 under reasonable values of T, the finite time horizon of interest.

Table 19: Effect of Demographics

	Omitted Category	Age	Gender	Household Size	Household Income
Habit Depreciation Rate	1.31	0.00	-0.24	0.13	-0.04
	[0.99, 1.65]	[-0.02, 0.01]	[-0.67, 0.20]	[-0.03, 0.29]	[-0.10, 0.01]
External Habit Mixture Coefficient	0.13	0.00	0.06	-0.04	-0.02
	[0.00, 0.25]	[-0.01, 0.01]	[-0.13, 0.22]	[-0.11, 0.03]	[-0.04, 0.00]
$-u_H/u_C$	0.67	0.00	-0.09	0.05	0.01
	[0.50, 0.85]	[-0.01, 0.01]	[-0.33, 0.14]	[-0.04, 0.13]	[-0.02, 0.04]
Hu_{HH}/u_H	6.62	-0.02	1.00	-0.58	0.23
	[5.94, 8.12]	[-0.09, 0.04]	[-0.02, 1.48]	[-0.95, 0.02]	[0.03, 0.44]
u_{CH}/u_{HH}	-0.91	0.00	0.10	0.05	0.02
	[-1.12, -0.68]	[-0.01, 0.01]	[-0.19, 0.40]	[-0.06, 0.16]	[-0.02, 0.06]
u_{CC}/u_{HH}	4.04	0.03	-0.78	-0.32	-0.04
	[2.98, 4.89]	[-0.03, 0.09]	[-1.50, 0.46]	[-0.86, 0.16]	[-0.22, 0.12]
$u_{C^{others}}/u_H$	1.07	-0.02	0.06	0.18	0.05
	[0.52, 1.64]	[-0.05, 0.01]	[-0.68, 0.81]	[-0.07, 0.46]	[-0.04, 0.14]
Time Discount Rate	0.09	0.00	0.12	0.02	0.00
	[-0.09, 0.25]	[-0.01, 0.00]	[-0.09, 0.35]	[-0.06, 0.10]	[-0.02, 0.03]

Notes: The omitted category is that of 40 year-old males who live in 3-member households with \$50,001 - \$60,000 annual household income. 95% HPDI below posterior mode estimates.

Table 20: Finite Horizon Estimates

	MAP	Mean	Median	95% or 99% HPDI
Habit Depreciation Rate	1.12	1.11	1.11	[0.90, 1.32]
External Habit Mixture Coefficient	0.16	0.16	0.16	[0.07, 0.26]
$-u_H/u_C$	0.59	0.60	0.59	[0.49, 0.71]
Hu_{HH}/u_H	7.66	7.77	7.75	[6.82, 8.73]
u_{CH}/u_{HH}	-0.86	-0.85	-0.86	[-1.00, -0.71]
u_{CC}/u_{HH}	3.83	3.85	3.85	[3.12, 4.57]
$u_{C_{others}}/u_H$	1.15	1.14	1.14	[0.78, 1.51]
$u_{C_{others}}/u_C$	-0.67	-0.68	-0.68	[-0.93, -0.42]
$u_{CH}u_H/u_{HH}u_C$	0.49	0.51	0.51	[0.34, 0.69]
$u_{CH}u_C/u_{CC}u_H$	0.37	0.38	0.37	[0.24, 0.56]
$Hu_Hu_{CH}/u_C\left(u_H+Hu_{HH}\right)$	0.45	0.45	0.45	[0.31, 0.61]
$Cu_Cu_{CH}/u_H\left(u_C+Cu_{CC}\right)$	-0.23	-0.24	-0.24	[-0.33, -0.16]
Time Discount Rate	0.15	0.14	0.14	[0.04, 0.25]

Notes: The time horizon is 30 years in the future, as I instruct the respondents in the survey "... think of ... 'Future' as the next 30 years."

under the finite-horizon elicitations and find that the estimates are almost exactly the same as those in the infinite horizon (Table 20).

6.3 Additional Attention Checks

I have already utilized the explicit attention checks to screen out respondents who did not understand the hypothetical situation or the monthly spending graphs through quizzes and deleted the responses of those who sped the survey and were located outside of the U.S. In this section I make use of implicit attention checks to see if a potential lack of attention biases my results. Because the implicit attention checks are not perfect proxies for attention, I apply them successively, from the relatively more reliable to the relatively less reliable.

At the end of the survey, I asked again the quiz on understanding of the basic hypothetical situation of the survey. There are 120 respondents in wave one and 54 in wave two who made at least one mistakes in answering the five-question quiz. Deleting these responses from my sample results in no significant change to my estimates (Table 21), except external habit no longer exists under the strict case, though still exists under the lenient case.

I asked demographic questions in both waves. Within the relatively moderate amount of time that separates the two waves, the demographics should not change. In other words, the time consistency of answers to the demographic questions can be used as an implicit attention check. Applying

Table 21: Estimates Using Subsample of No Failed Quiz

	MAP	Mean	Median	95% or 99% HPDI
Habit Depreciation Rate	1.11	1.12	1.12	[0.86, 1.37]
External Habit Mixture Coefficient	0.08	0.10	0.10	[0.00, 0.21]
$-u_H/u_C$	0.69	0.70	0.70	[0.56, 0.84]
Hu_{HH}/u_H	8.21	8.30	8.27	[7.02, 9.61]
u_{CH}/u_{HH}	-0.80	-0.81	-0.81	[-1.00, -0.60]
u_{CC}/u_{HH}	4.45	4.42	4.42	[2.82, 5.97]
$u_{C_{others}}/u_H$	1.53	1.52	1.52	[0.80, 2.27]
$u_{C_{others}}/u_C$	-1.02	-1.07	-1.05	[-1.64, -0.52]
$u_{CH}u_H/u_{HH}u_C$	0.56	0.57	0.56	[0.33, 0.82]
$u_{CH}u_C/u_{CC}u_H$	0.24	0.27	0.26	[0.13, 0.51]
$Hu_Hu_{CH}/u_C(u_H+Hu_{HH})$	0.50	0.51	0.50	[0.30, 0.73]
$Cu_Cu_{CH}/u_H(u_C+Cu_{CC})$	-0.18	-0.20	-0.19	[-0.37, -0.10]
$\operatorname{sgn}(Q_H)$	-1.00	-1.00	-1.00	[-1.00, -1.00]
$\operatorname{sgn}(Q_{EH})$ (strict)	1.00	0.11	1.00	0.55
$\operatorname{sgn}(Q_{EH})$ (lenient)	-1.00	-1.00	-1.00	[-1.00, -1.00]
Time Discount Rate	0.11	0.11	0.11	[-0.06, 0.26]

Notes: 99% HPDI are reported for the seven statistics for testing additive and multiplicative habits and existence of external habit. 95% HPDI are reported for the rest parameters. In cases where it is not significant at the 90% level, a p-value of 0 is shown.

Table 22: Estimates Using Subsample of No Demographic Mistake

	MAP	Mean	Median	95% or 99% HPDI
Habit Depreciation Rate	1.15	1.13	1.13	[0.85, 1.41]
External Habit Mixture Coefficient	0.10	0.12	0.12	[0.00, 0.24]
$-u_H/u_C$	0.67	0.67	0.67	[0.52, 0.82]
Hu_{HH}/u_H	8.35	8.47	8.45	[7.27, 9.92]
u_{CH}/u_{HH}	-0.87	-0.86	-0.86	[-1.06, -0.65]
u_{CC}/u_{HH}	4.20	4.15	4.15	[2.47, 5.86]
$u_{C_{others}}/u_H$	1.45	1.44	1.43	[0.64, 2.22]
$u_{C_{others}}/u_C$	-0.91	-0.96	-0.94	[-1.54, -0.41]
$u_{CH}u_H/u_{HH}u_C$	0.57	0.57	0.57	[0.34, 0.83]
$u_{CH}u_C/u_{CC}u_H$	0.29	0.33	0.31	[0.14, 0.67]
$Hu_Hu_{CH}/u_C\,(u_H+Hu_{HH})$	0.51	0.51	0.51	[0.30, 0.75]
$Cu_Cu_{CH}/u_H\,(u_C+Cu_{CC})$	-0.20	-0.23	-0.22	[-0.46, -0.10]
$\text{sgn}\,(Q_H)$	-1.00	-1.00	-1.00	[-1.00, -1.00]
$\text{sgn}\,(Q_{EH})$ (strict)	-1.00	-0.31	-1.00	0.34
$\text{sgn}\,(Q_{EH})$ (lenient)	-1.00	-1.00	-1.00	99: [-1.00, -1.00]
Time Discount Rate	0.12	0.11	0.12	[-0.05, 0.27]

Notes: 99% HPDI are reported for the seven statistics for testing additive and multiplicative habits and existence of external habit. 95% HPDI are reported for the rest parameters. In cases where it is not significant at the 90% level, a p-value for the statistic equal to 0 is shown.

this deletes another 18 responses from the sample. This does not change my estimates (Table 22) except, again, that the evidence for existence of external habit is weaker.

A third implicit attention check is that people should choose the same experience option when there is not any difference between the universes. In the time discount rate question[51] past spendings are the same in both universes, where the respondents should choose same past experience. This leads me to further delete 104 and 19 responses in waves one and two, respectively. The estimates remain in line with my baseline estimates (Table 23). Two points worth noting. The external habit exists at 90% credible level in the strict case, as in my main results. The credible intervals expand as a result of the much smaller sample size. This reduces the precision of some of my statistics for the tests. However, the rest of the statistics remain accurate enough to keep my results robust.

Finally, I use a measure of the consistency of answers across waves as an attention check. Considering this attention check involves more speculation, I delete only those who give at least

[51] See section C of the appendix.

Table 23: Estimates Using Subsample of Same Past Experience

	MAP	Mean	Median	95% or 99% HPDI
Habit Depreciation Rate	1.27	1.27	1.27	[0.84, 1.74]
External Habit Mixture Coefficient	0.27	0.27	0.26	[0.00, 0.50]
$-u_H/u_C$	0.49	0.50	0.50	[0.30, 0.69]
Hu_{HH}/u_H	9.12	8.78	8.87	[7.35, 10.00]
u_{CH}/u_{HH}	-0.69	-0.68	-0.68	[-0.95, -0.41]
u_{CC}/u_{HH}	4.33	4.41	4.39	[2.31, 6.57]
$u_{C_{others}}/u_H$	0.93	0.98	0.98	[-0.20, 2.12]
$u_{C_{others}}/u_C$	-0.44	-0.49	-0.47	[-1.11, 0.12]
$u_{CH}u_H/u_{HH}u_C$	0.32	0.34	0.33	[0.11, 0.60]
$u_{CH}u_C/u_{CC}u_H$	0.22	0.35	0.31	[0.06, 0.92]
$Hu_Hu_{CH}/u_C\left(u_H+Hu_{HH}\right)$	0.28	0.30	0.30	[0.10, 0.54]
$Cu_Cu_{CH}/u_H\left(u_C+Cu_{CC}\right)$	-0.14	-0.17	-0.16	[-0.44, -0.04]
$\mathrm{sgn}\left(Q_H\right)$	-1.00	-0.97	-1.00	95: [-1.00, -1.00] 99: [-1.00, 1.00]
$\mathrm{sgn}\left(Q_{EH}\right)$ (strict)	-1.00	-0.85	-1.00	90: [-1.00, -1.00] 95: [-1.00, 1.00]
$\mathrm{sgn}\left(Q_{EH}\right)$ (lenient)	-1.00	-1.00	-1.00	99: [-1.00, -1.00]
Time Discount Rate	0.10	0.10	0.10	[-0.27, 0.46]

Notes: 99% HPDI are reported for the seven statistics for testing additive and multiplicative habits and existence of external habit. 95% HPDI are reported for the rest parameters. Additional HPDI of relevant level is also shown to help determine the credible level.

Table 24: Estimates Using Sample of No Polar Answer

	MAP	Mean	Median	95% or 99% HPDI
Habit Depreciation Rate	1.43	1.43	1.43	[0.95, 1.96]
External Habit Mixture Coefficient	0.15	0.22	0.20	[0.00, 0.48]
$-u_H/u_C$	0.54	0.53	0.53	[0.25, 0.78]
Hu_{HH}/u_H	8.82	8.54	8.61	[6.94, 10.00]
u_{CH}/u_{HH}	-0.73	-0.72	-0.73	[-0.99, -0.44]
u_{CC}/u_{HH}	4.69	4.56	4.57	[1.91, 7.23]
$u_{C_{others}}/u_H$	1.02	1.07	1.05	[-0.25, 2.44]
$u_{C_{others}}/u_C$	-0.45	-0.56	-0.53	[-1.36, 0.20]
$u_{CH}u_H/u_{HH}u_C$	0.36	0.38	0.37	[0.08, 0.71]
$u_{CH}u_C/u_{CC}u_H$	0.10	0.34	0.31	[0.07, 1.41]
$Hu_Hu_{CH}/u_C\left(u_H+Hu_{HH}\right)$	0.33	0.34	0.33	[0.08, 0.65]
$Cu_Cu_{CH}/u_H\left(u_C+Cu_{CC}\right)$	-0.16	-0.19	-0.17	[-0.67, -0.03]
$\text{sgn}\left(Q_H\right)$	-1.00	-0.99	-1.00	99: [-1.00, -1.00]
$\text{sgn}\left(Q_{EH}\right)$ (strict)	-1.00	-0.32	-1.00	0.34
$\text{sgn}\left(Q_{EH}\right)$ (lenient)	-1.00	-1.00	-1.00	99: [-1.00, -1.00]
Time Discount Rate	0.02	-0.05	-0.02	[-0.62, 0.47]

Notes: 99% HPDI are reported for the seven statistics for testing additive and multiplicative habits and existence of external habit. 95% HPDI are reported for the rest parameters. Additional HPDI of relevant level is also shown to help determine the credible level. In cases where it is not significant at the 90% level, a p-value for the statistic equal to 0 is shown.

one polar responses, responses that correspond to the first (last) extreme range of parameter values in wave one and the last (first) in wave two. This leads to the deletion of another 31 responses from both waves, which results in further inflation of the HPDIs for my estimates but again my estimates are not significantly different and my results remain robust (Table 24).

6.4 Response Error with Non-Zero and Wave-Varying Mean

In the statistical model, I assume that the response error has a zero mean across both waves of survey. Relaxing this assumption, I will have a statistical model with response errors of non-zero means that potentially vary across waves. Without loss of generality,[52] the joint distribution of

[52] Only two means, one for each wave, can be identified. So the specification here identifying the difference of the means is equivalent to a specification which specifies the two means using two parameters, one for each mean. If the two means are different, then I will find μ_ε to be statistically different from 0.

Table 25: Response Error Mean in Wave One

μ_ε of	MAP	Mean	Median	95% HPDI
Habit Depreciation Rate	-0.01	-0.02	-0.02	[-0.25, 0.21]
External Habit Mixture Coefficient	-0.05	-0.04	-0.04	[-0.13, 0.06]
$-u_H/u_C$	-0.01	-0.01	-0.01	[-0.10, 0.07]
Hu_{HH}/u_H	-0.85	-1.15	-1.03	[-3.06, 0.48]
u_{CH}/u_{HH}	0.08	0.08	0.08	[-0.07, 0.23]
u_{CC}/u_{HH}	-0.41	-0.41	-0.40	[-1.14, 0.34]
$u_{C_{others}}/u_H$	-0.13	-0.13	-0.13	[-0.52, 0.25]
Time Discount Rate	-0.05	-0.05	-0.05	[-0.16, 0.07]

Notes: 99% HPDI are reported for the seven statistics for testing additive and multiplicative habits and existence of external habit. 95% HPDI are reported for the rest parameters. Additional HPDI of relevant level is also shown to help determine the credible level. In cases where it is not significant at the 90% level, a p-value of equaling 0 is shown.

parameter $\tilde{x}$ for individual i in both waves becomes

$$\begin{bmatrix} \tilde{x}_{i,1} \\ \tilde{x}_{i,2} \end{bmatrix} \sim \mathcal{N}\left(\begin{bmatrix} \mu_x + \mu_\varepsilon \\ \mu_x - \mu_\varepsilon \end{bmatrix}, \begin{bmatrix} \sigma_x^2 + \sigma_{\varepsilon_x}^2 + \sigma_{\varepsilon_{x,1}}^2 & \sigma_x^2 + \sigma_{\varepsilon_x}^2 \\ \sigma_x^2 + \sigma_{\varepsilon_x}^2 & \sigma_x^2 + \sigma_{\varepsilon_x}^2 + \sigma_{\varepsilon_{x,2}}^2 \end{bmatrix} \right)$$

.

The estimates of the means of the response errors in wave one or equivalently negative of the means of the response errors in wave two are indistinguishable from zero at the 5% level (Table 25). This implies that my estimates are robust to the non-zero-wave-varying-mean response errors, which is exactly what I find (Table 26).

7 Conclusion

In this paper, I provide an extensive set of micro evidence for habit formation. I find that people's spending behaviors exhibit habit formation, partly explaining why adding habit formation tends to improve the explanatory power of models. Considering that there are phenomena current habit formation models are having a hard time matching, I suggest future models should be built onto habit formation, rather than throw it away.

I estimate that habit depreciates about two-thirds per year. Future habit formation models should match or at least check how the model performs under this speed of habit depreciation. Specifying this parameter to the value can potentially reduce the fit between model and data. I believe that signals that habit formation itself is not enough to fully explain the data at hand, necessitating introduction of additional features to the model.

Table 26: Estimates under Non-Zero and Wave-Varying Mean of Response Error

	MAP	Mean	Median	95% or 99% HPDI
Habit Depreciation Rate	1.11	1.12	1.12	[0.86, 1.36]
External Habit Mixture Coefficient	0.20	0.19	0.19	[0.07, 0.31]
$-u_H/u_C$	0.63	0.63	0.62	[0.51, 0.75]
Hu_{HH}/u_H	8.55	8.81	8.69	[7.03, 10.85]
u_{CH}/u_{HH}	-0.90	-0.89	-0.89	[-1.05, -0.72]
u_{CC}/u_{HH}	4.03	4.05	4.05	[3.15, 5.00]
$u_{C_{others}}/u_H$	1.14	1.14	1.14	[0.74, 1.59]
$u_{C_{others}}/u_C$	-0.70	-0.71	-0.71	[-1.02, -0.42]
$u_{CH}u_H/u_{HH}u_C$	0.55	0.56	0.55	[0.37, 0.76]
$u_{CH}u_C/u_{CC}u_H$	0.34	0.36	0.35	[0.22, 0.56]
$Hu_Hu_{CH}/u_C(u_H+Hu_{HH})$	0.50	0.50	0.50	[0.33, 0.68]
$Cu_Cu_{CH}/u_H(u_C+Cu_{CC})$	-0.23	-0.23	-0.23	[-0.35, -0.15]
$\text{sgn}(Q_H)$	-1.00	-0.97	-1.00	95: [-1.00, -1.00] 99: [-1.00, 1.00]
$\text{sgn}(Q_{EH})$ (strict)	-1.00	-0.85	-1.00	90: [-1.00, -1.00] 95: [-1.00, 1.00]
$\text{sgn}(Q_{EH})$ (lenient)	-1.00	-1.00	-1.00	99: [-1.00, -1.00]
Time Discount Rate	0.18	0.18	0.18	[0.04, 0.34]

Notes: 99% HPDI are reported for the seven statistics for testing additive and multiplicative habits and existence of external habit. 95% HPDI are reported for the rest parameters. Additional HPDI of relevant level is also shown to help determine the credible level.

I also find that none of the current habit models is consistent with people's behavior because their specific utility functions fail to pass the four tests I propose. This justifies a search for a habit utility function that matches the micro evidence, which potentially can explain facts current habit models fail to explain.

I estimate that external habit exists and accounts for a small fraction (17%) of the habit. This implies that in terms of micro evidence, internal habit is a better choice than external habit. Better still, a composition of internal and external habits with the estimated weights could potentially deliver an even superior match with people's behavior.

I provide evidence that habit formation is as important as keeping up with the Joneses, that both catching and keeping up with the Joneses exist in people's behavior, and that keeping up with the Joneses dominates altruism.

Combining habit formation and keeping up with the Joneses can generate the patterns of income (consumption) and happiness as highlighted by the Easterlin paradox. This implies that income can increase with happiness, but only for a while before the wear-off effect induced by habituation and social comparison ends the happiness-enhancing phase. Level and transition effects lead to the cross-sectional and short-run positive correlations between income and happiness while plateau effect the long-run nil correlation. Even though happiness only increases for a while, continued economic growth is necessary to maintain a certain level of happiness.

Future research could explore how my results compare to estimates from different populations. Heterogeneous cross-country estimates could potentially explain the cross-country heterogeneities of income-happiness dynamics. It is also interesting to see how other ways of eliciting the same preference parameters I elicited here affect the results.

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Appendices

A Aggregation

What does the elicited preference parameters of individual respondents tell us about the preference parameters of the representative agent? This question is of particular interest because almost all current models with habit formation assume a representative agent. In this section, I prove that the representative agent's preference parameters are averages of the individuals' preference parameters.

To aggregate individuals, the welfare of the individuals need to be comparable with that of each other (comparability) and the aggregate agent's welfare should represent the sum of individuals' welfare (representativeness). To formalize these two ideas, I assume that at the homogenous steady state of $\bar{C}_i = \bar{H}_i = \$5,000\ \forall i$, spending an extra dollar,[53] while holding habit constant, brings the same marginal utility to every one: $u_{i,C}\left(\bar{C}_i, \bar{H}_i\right) = u_{j,C}\left(\bar{C}_j, \bar{H}_j\right)\ \forall i, j$.

With the comparability of individuals' utilities, the representativeness of the representative agent means that $Nu_R\left(C_R, H_R\right) = \sum_i u_i\left(C_i, H_i\right)$ when $C_R = C_i = A$ and $H_R = H_i = B\ \forall i$ and $\forall A, B$ in the domains of the utility functions, where N is the number of individuals in the economy. That is, when the heterogeneities in behaviors (consumption and habit) are homogenized, the representative agent is the average individual agent. To see what this condition means, first note that the difference between a representative agent model and a heterogeneous agents model is that in the former everyone in the economy is the same while in the latter each individual can be different. Imagine that everyone in the heterogeneous economy becomes the same (i.e., homogeneous in consumption, habit, and utility function, etc), the representative agent model should behave exactly the same as the homogenous agent model, and hence the equality of $Nu_R\left(C_R, H_R\right) = \sum_i u_i\left(C_i, H_i\right)$. Now, allowing the individual to be heterogeneous along the utility function dimension after the normalization of the comparability condition, this representativeness condition simply requires that the representative agent represents the individuals along the welfare dimension, after controlling for consumption and habit.

A.1 Aggregation of Habit Depreciation Rate

Even though habit depreciation rate (θ) and habit (H) are mapped one to one at each instant of time[54] for any given consumption profile, there are infinitely many pairs of them that satisfy the representative agent's habit evolution ($\dot{H}_R = \theta_R\left(C_R - H_R\right)$), individuals' habit evolutions ($\dot{H}_i = \theta_i\left(C_i - H_i\right)$), the comparability condition, and the representativeness condition. The intuition is that while H depends on the habit depreciation rate its steady state level not. In other words,

[53] An epsilon dollar, to be exact.

[54] Before reaching a steady state.

different θ leads to different H before a steady state is reached and this difference vanishes after a steady state is reached.

To find the mapping between aggregate habit depreciation rate (θ_R) and individual habit depreciation rate (θ_i), imagine that everyone starts at the homogenous steady state and increases consumption by a same iota amount. That is, starting from $C_i = C_j = C_R = H_i = H_j = H_R\ \forall i, j$, increase consumption by the iota amount $\Delta C_i = \Delta C_j = \Delta C_R\ \forall i, j$. I would have the change of utilities being

$$\begin{aligned}\Delta u_R(C_R, H_R) &= u_{R,C}(C_R, H_R)\,\Delta C_R + u_{R,H}(C_R, H_R)\,\Delta H_R \\ &= u_{R,C}(C_R, H_R)\,\Delta C_R + u_{R,H}(C_R, H_R)\,\theta_R \Delta C_R\end{aligned}$$

and

$$\begin{aligned}\Delta u_i(C_i, H_i) &= u_{i,C}(C_i, H_i)\,\Delta C_i + u_{i,H}(C_i, H_i)\,\Delta H_i \\ &= u_{i,C}(C_i, H_i)\,\Delta C_i + u_{i,H}(C_i, H_i)\,\theta_i \Delta C_i\end{aligned}$$

.

To have the representative agent represents the total welfare of individual agents, I need

$$N \Delta u_R(C_R, H_R) = \sum_i \Delta u_i(C_i, H_i)$$

which implies

$$u_{R,C}(C_R, H_R)\,\Delta C_R + u_{R,H}(C_R, H_R)\,\theta_R \Delta C_R = \frac{1}{N} \sum_i \left[u_{i,C}(C_i, H_i)\,\Delta C_i + u_{i,H}(C_i, H_i)\,\theta_i \Delta C_i \right]$$

. Since $\Delta C_i = \Delta C_j = \Delta C_R$ and $u_{R,C}(C_R, H_R) = u_{i,C}(C_i, H_i)$ (comparability) $\forall i, j$,

$$\begin{aligned}\frac{u_{R,H}(C_R, H_R)}{u_{R,C}(C_R, H_R)} \theta_R &= \frac{1}{N} \sum_i \frac{u_{i,H}(C_i, H_i)}{u_{i,C}(C_i, H_i)} \theta_i \\ &= \frac{1}{N} \sum_i \frac{u_{i,H}(C_i, H_i)}{u_{i,C}(C_i, H_i)} \cdot \frac{1}{N} \sum_i \theta_i\end{aligned}$$

where the second equality holds because of the independence between slope of indifference curve and habit depreciation rate. With $u_{R,H}(C_R, H_R) = \frac{1}{N} \sum_i u_{i,H}(C_i, H_i)$ (see section A.2) and $u_{R,C}(C_R, H_R) = u_{i,C}(C_i, H_i)\ \forall i$, I have

$$\theta_R = \frac{1}{N} \sum_i \theta_i$$

. That is, the representative agent's habit depreciation rate is the average of the individuals' habit depreciation rates.

A.2 Aggregation of Ratios of Utility Derivatives

First, I derive the relationship between utility derivatives of the representative agent and the heterogeneous agents at the baseline steady state ($\bar{C}_R = \bar{H}_R = \bar{C}_i = \bar{H}_i\ \forall i$). Since $Nu_R(C_R, H_R) = \sum_i u_i(C_i, H_i)$ for $C_R = C_i = A$ and $H_R = H_i = B\ \forall i$ and $\forall A, B$ in the domains of the utility functions, utility derivatives of the representative agent is the average of the the utility derivatives of the individuals:

$$u_{R,X}(C_R, H_R) = \frac{1}{N}\sum_i u_{i,X}(C_i, H_i) \xrightarrow{p} E(u_{i,X}(C_i, H_i))$$

where X indicates the variable and order of the utility derivatives (e.g., C, H, CC, CH, HH).

Next, I derive the relationship between utility ratios of the representative agent and the heterogeneous agents.

1. Under the normalization of $u_{R,C}(\bar{C}, \bar{H}) = u_{i,C}(\bar{C}, \bar{H})$, without loss of generality say this marginal utility is of level $\bar{u}$, the distribution of $-\frac{u_{i,H}(\bar{C},\bar{H})}{u_{i,C}(\bar{C},\bar{H})}$ is simply the distribution of $-u_{i,H}(\bar{C}, \bar{H})$ scaled by $\bar{u}$. Thus, $E(u_{i,H})$ can be calculated from

$$E(u_{i,H}) = -E\left(-\frac{u_{i,H}}{u_{i,C}} \cdot u_{i,C}\right) = -E\left(-\frac{u_{i,H}}{u_{i,C}}\right) \cdot u_{i,C} = -\mu_{-\frac{u_{i,H}}{u_{i,C}}} \cdot \bar{u}$$

   where $\mu_{-\frac{u_{i,H}}{u_{i,C}}}$ is the mean of the preference parameter $-\frac{u_{i,H}}{u_{i,C}}$ across individuals.

2. The distribution of $u_{i,HH}$ is the distribution of $\frac{Hu_{i,HH}}{u_{i,H}}$ multiplied by $u_{i,H}$ and scaled by H. Since the parameters are independent,

$$E(u_{i,HH}) = E\left(\frac{Hu_{i,HH}}{u_{i,H}} \cdot u_{i,H} \cdot \frac{1}{H}\right) = E\left(\frac{Hu_{i,HH}}{u_{i,H}}\right) E(u_{i,H}) \frac{1}{H} = \mu_{\frac{Hu_{i,HH}}{u_{i,H}}} \cdot \left(-\mu_{-\frac{u_{i,H}}{u_{i,C}}}\right) \cdot \bar{u} \cdot \frac{1}{H}$$

   .

3. Similarly,

$$E(u_{i,CH}) = E\left(\frac{u_{i,CH}}{u_{i,HH}} \cdot u_{i,HH}\right) = E\left(\frac{u_{i,CH}}{u_{i,HH}}\right) E(u_{i,HH}) = \mu_{\frac{u_{i,CH}}{u_{i,HH}}} \cdot \mu_{\frac{Hu_{i,HH}}{u_{i,H}}} \cdot \left(-\mu_{-\frac{u_{i,H}}{u_{i,C}}}\right) \cdot \bar{u} \cdot \frac{1}{H}$$

   ,

$$E(u_{i,CC}) = E\left(\frac{u_{i,CC}}{u_{i,HH}} \cdot u_{i,HH}\right) = E\left(\frac{u_{i,CC}}{u_{i,HH}}\right) E(u_{i,HH}) = \mu_{\frac{u_{i,CC}}{u_{i,HH}}} \cdot \mu_{\frac{Hu_{i,HH}}{u_{i,H}}} \cdot \left(-\mu_{-\frac{u_{i,H}}{u_{i,C}}}\right) \cdot \bar{u} \cdot \frac{1}{H}$$

   , and

$$E(u_{i,C_{others}}) = E\left(\frac{u_{i,C_{others}}}{u_{i,C}} \cdot u_{i,C}\right) = E\left(\frac{u_{i,C_{others}}}{u_{i,C}}\right) \cdot \bar{u} = \mu_{\frac{u_{i,C_{others}}}{u_{i,C}}} \cdot \bar{u}$$

   .

4. With these I can calculate

$$-\frac{u_{R,H}}{u_{R,C}} = -\frac{E\left(u_{i,H}\right)}{E\left(u_{i,C}\right)} = -\frac{E\left(u_{i,H}\right)}{\bar{u}} = \mu_{-\frac{u_{i,H}}{u_{i,C}}}$$

,

$$\frac{Hu_{R,HH}}{u_{R,H}} = \frac{HE\left(u_{i,HH}\right)}{E\left(u_{i,H}\right)} = \frac{H\mu_{\frac{Hu_{i,HH}}{u_{i,H}}}\left(-\mu_{-\frac{u_{i,H}}{u_{i,C}}}\right)\bar{u}\frac{1}{H}}{-\mu_{-\frac{u_{i,H}}{u_{i,C}}}\bar{u}} = \mu_{\frac{Hu_{i,HH}}{u_{i,H}}}$$

,

$$\frac{u_{R,CH}}{u_{R,HH}} = \frac{E\left(u_{i,CH}\right)}{E\left(u_{i,HH}\right)} = \frac{\mu_{\frac{u_{i,CH}}{u_{i,HH}}}\mu_{\frac{Hu_{i,HH}}{u_{i,H}}}\left(-\mu_{-\frac{u_{i,H}}{u_{i,C}}}\right)\bar{u}\frac{1}{H}}{\mu_{\frac{Hu_{i,HH}}{u_{i,H}}}\left(-\mu_{-\frac{u_{i,H}}{u_{i,C}}}\right)\bar{u}\frac{1}{H}} = \mu_{\frac{u_{i,CH}}{u_{i,HH}}}$$

,

$$\frac{u_{R,CC}}{u_{R,HH}} = \frac{E\left(u_{i,CC}\right)}{E\left(u_{i,HH}\right)} = \frac{\mu_{\frac{u_{i,CC}}{u_{i,HH}}}\mu_{\frac{Hu_{i,HH}}{u_{i,H}}}\left(-\mu_{-\frac{u_{i,H}}{u_{i,C}}}\right)\bar{u}\frac{1}{H}}{\mu_{\frac{Hu_{i,HH}}{u_{i,H}}}\left(-\mu_{-\frac{u_{i,H}}{u_{i,C}}}\right)\bar{u}\frac{1}{H}} = \mu_{\frac{u_{i,CC}}{u_{i,HH}}}$$

, and

$$\frac{u_{R,C_{others}}}{u_{R,C}} = \frac{E\left(u_{i,C_{others}}\right)}{E\left(u_{i,C}\right)} = \frac{E\left(u_{i,C_{others}}\right)}{\bar{u}} = \mu_{\frac{u_{i,C_{others}}}{u_{i,C}}}$$

.

In summary, the representative agent's ratios of utility derivatives are simply the means of individuals' ratios of utility derivatives.

A.3 Aggregation of External Habit Mixture Coefficient

Imagine that everyone increases his/her consumption by a same iota amount so that the representative agent also increases her consumption by this same amount. Looking at the representativeness condition reveals that the changes in utilities are such that

$$N\left[u_{R,C}\left(C_R,H_R\right)\Delta C_R + u_{R,H}\left(C_R,H_R\right)\Delta H_R\right] = \sum_i \left[u_{i,C}\left(C_i,H_i\right)\Delta C_R + u_{i,H}\left(C_i,H_i\right)\Delta H_i\right]$$

. Utilizing the comparability condition to get

$$N\frac{u_{R,H}\left(C_R,H_R\right)}{u_{R,C}\left(C_R,H_R\right)}\Delta H_R = \sum_i \frac{u_{i,H}\left(C_i,H_i\right)}{u_{i,C}\left(C_i,H_i\right)}\Delta H_i$$

. Since $\Delta H_R = \theta_R (1-\omega_R)$ and $\Delta H_i = \theta_i (1-\omega_i)$, I have

$$\begin{aligned}
\frac{u_{R,H}(C_R,H_R)}{u_{R,C}(C_R,H_R)}\theta_R(1-\omega_R) &= \frac{1}{N}\sum_i \frac{u_{i,H}(C_i,H_i)}{u_{i,C}(C_i,H_i)}\theta_i(1-\omega_i) \\
&= \left(\frac{1}{N}\sum_i \frac{u_{i,H}(C_i,H_i)}{u_{i,C}(C_i,H_i)}\right)\cdot\left(\frac{1}{N}\sum_i \theta_i\right)\cdot\left(\frac{1}{N}\sum_i (1-\omega_i)\right)
\end{aligned}$$

where the second equality because of the independence between the preference parameters. By $\frac{u_{R,H}(C_R,H_R)}{u_{R,C}(C_R,H_R)} = \frac{1}{N}\sum_i \frac{u_{i,H}(C_i,H_i)}{u_{i,C}(C_i,H_i)}$ and $\theta_R = \frac{1}{N}\sum_i \theta_i$, I have

$$\omega_R = \frac{1}{N}\sum_i \omega_i$$

.

B Equivalence of Linear and Nonlinear Habit Evolutions

In this section, I show that the model with the linear habit evolution (Model L below) and models with nonlinear habit evolutions (Model N below) are equivalent. The rationale lies in that linear habit (H) and nonlinear habit ($\mathscr{H}$) are two measurements of one same thing - habit. Just like using foot and meter to measure length does not change the effect of length, using H and $\mathscr{H}$ to measure habit will not change the effect of habit (on optimal choices).[55]

- Model L:

$$\begin{gathered}
\mathbb{E}_0 \int_0^\infty e^{-\rho t} u(C,H)\, dt \\
s.t.\ \ \dot{H} = \theta (C-H)
\end{gathered}$$

- Model N:

$$\begin{gathered}
\mathbb{E}_0 \int_0^\infty e^{-\rho t} v(C,\mathscr{H})\, dt \\
s.t.\ \ \dot{\mathscr{H}} = f(C,\mathscr{H})
\end{gathered}$$

  where f can be a nonlinear function of C and $\mathscr{H}$.

Note that $H_t = h(C_0, H_0, t)$ if $C_t = C_{t+1}$ for all $t \geq 0$ (subscripts are time indices). Similarly, $\mathscr{H}_t = k(C_0, \mathscr{H}_0, t)$ if $C_t = C_{t+1}$ for all $t \geq 0$. That is, when the consumption path does not change, H_t and $\mathscr{H}_t$ are functions of only time while C_0, H_0, and $\mathscr{H}_0$ are their parameters.

[55]For example, the geometric habit evolution as in Kozicki and Tinsley (2002) synchronizes with the linear habit evolution of Model L.

Definition 1. Monotonicities of two functions are entangled with respect to a variable if 1) the two functions share this variable as an argument , 2) when one function is monotonic in the argument, the other function is also monotonic in the argument and 3) when one function is not weakly monotonic in the argument, the other function is also not weakly monotonic in the argument.

Because H and $\mathscr{H}$ two measurements of one fundamental - habit, they change at the same time (though in potentially different ways) when habit changes and stop changing when habit stops changing. By Definition 1, their monotonicities[56] are entangled with respect to time.

Definition 2. Two models are observationally equivalent if they lead to a same set of optimal choices.

Proposition 11. *Model L and Model N are observationally equivalent if monotonicities of H and $\mathscr{H}$ are entangled with respect to time.*

Proof. Since H and $\mathscr{H}$ are entangled monotonically with respect to time, without loss of generality, suppose that H and $\mathscr{H}$ are monotonic from period 0 to period T and flat afterwards (i.e., remain at constant levels), say at levels $\bar{H}$ and $\bar{\mathscr{H}}$. Suppose also consumption changes at period 0 and stays at that level: $C_t = C_{t+1} \neq C_{-1}$ for all $t \geq 0$. As a result, $H_t = a(t|C_0,H_0)$ and $\mathscr{H}_t = b(t|C_0,H_0)$ where $a(\cdot)$ and $b(\cdot)$ are monotonic functions of t for $0 \leq t \leq T$ and flat for $t > T$, where T is the instant habit reaches its new steady-state.

Since

$$\mathscr{H}_t = b(t|C_0,H_0) = b\left(a^{-1}(a(t|C_0,H_0))|C_0,H_0\right) = b\left(a^{-1}(H_t)|C_0,H_0\right)$$

for $0 \leq t \leq T$ and

$$\mathscr{H}_t = \frac{\bar{\mathscr{H}}}{\bar{H}} H_t$$

for $t > T$, there always exists an injective function G that maps H_t into $\mathscr{H}_t$:

$$\mathscr{H}_t = G(H_t) = \begin{cases} b\left(a^{-1}(H_t)|C_0,H_0\right) & 0 \leq t \leq T \\ \frac{\bar{\mathscr{H}}}{\bar{H}} H_t & t > T \end{cases}$$

. For other patterns of monotonicities of the two functions (e.g. flat to monotonic to flat to monotonic, etc), the function G can be derived analogously.

Since

$$v(C(t),\mathscr{H}(t)) = v(C(t),G(H(t))) \equiv u(C(t),H(t))$$

, Model N gives the same utility as Model L for any consumption path.

[56] That is, H' and $\mathscr{H}'$ can equal to 0 but they will not change sign: i.e., $H' \cdot \mathscr{H}'$ does not change sign around region that $H' \cdot \mathscr{H}' = 0$.

When consumption path is not constant over time, the above remains true. To see this, start from the period when consumption is changed for the last time and apply the above logic to get the same utility starting from that period onwards from the two models. Then go back to the period when the consumption is changed for the second to last time and apply the above logic. Same utility results again for the two models. Continue this process until the first period of interest.

Since the utilities from the two models are the same, the consumption choices generated from these two models coincide. Suppose not. That is, the two models generate different optimal consumption paths, $\{C_L^*\} \neq \{C_N^*\}$ for at least one instant, where

$$\{C_L^*\} = \arg\max_{\{C\}} \mathbb{E}_0 \int_0^\infty e^{-\rho t} u(C,H)\, dt \equiv \arg\max_{\{C_L\}} U(\{C_L\}, H_0)$$

and

$$\{C_N^*\} = \arg\max_{\{C\}} \mathbb{E}_0 \int_0^\infty e^{-\rho t} v(C,\mathscr{H})\, dt \equiv \arg\max_{\{C_N\}} V(\{C_N\}, \mathscr{H}_0)$$

. If $U(\{C_L^*\}, H_0) \neq V(\{C_N^*\}, \mathscr{H}_0)$, at least one of the two consumption paths is not the optimal solution, contradicting that both of them are optimal solutions. If $U(\{C_L^*\}, H_0) = V(\{C_N^*\}, \mathscr{H})$, then the consumption path $\{C_L^*\}$ will also be a solution to the Model N while $\{C_N^*\}$ also a solution to Model L. Therefore, $\{C_H^*\}$ and $\left\{C_{\mathscr{H}}^*\right\}$ are both solutions to the two models. In other words, the two models have the same set of solutions. Thus, by Definition 2, the two models are observationally equivalent. $\square$

Since the monotonicities of H and $\mathscr{H}$ are entangled with respect to time, Model L and Model N are observationally equivalent.

C Elicitation of Time Discount Rate

The time discount rate is only of indirect interest[57] so it is not in the main text and relegated to here.

To elicit the time discount rate, I increase spending in the next year and the year after next year. The resulting survey question has monthly spending graphs as in Figure 22.

Proposition 12. *Under exact elicitation, a respondent chooses Universe One over Universe Two for a better future experience in the time discount rate question if* $\rho > -\ln \frac{\Delta e}{\Delta f}$.[58]

Estimation pins down a value of about 0.15 for the mean time discount rate (Table 27).

[57] That is, helping the estimation of other preference parameters.

[58] $\Delta e = \$2,000$ and $\Delta f = \$2,200$ in the example of Figure 22.

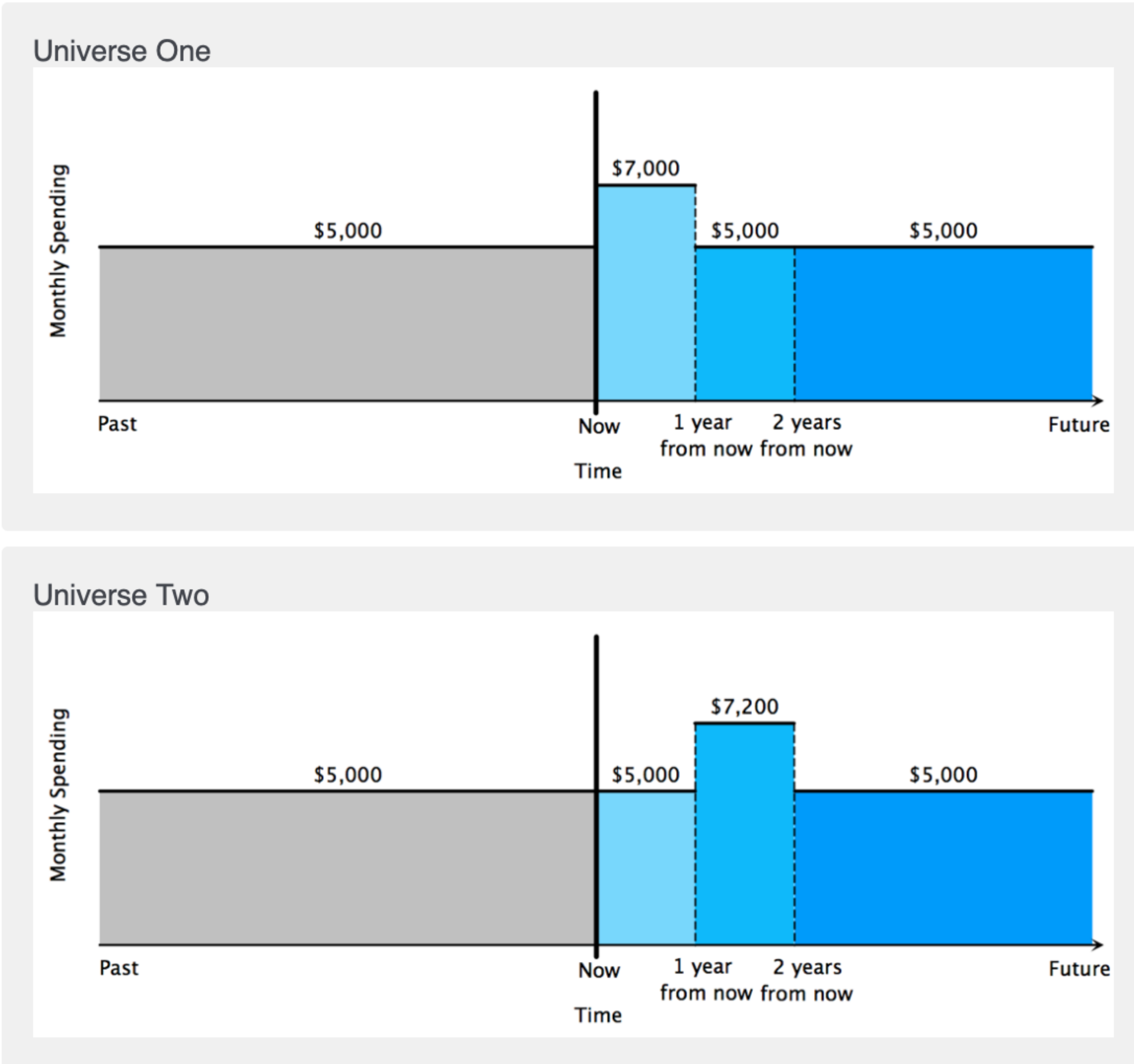

Figure 22: Monthly Spending Graphs - Time Discount Rate

Table 27: Estimate of Time Discount Rate

	MAP	Mean	Median	95% HPDI
ρ	0.15	0.14	0.14	[0.04, 0.25]

D Proofs

D.1 Lemmas

I prove three lemmas that will be used in proving the propositions.

Lemma 1. *For $a,b,c\in\mathbb{R}$, if $a(a+b)>0$, then $a(a+cb)>0$ as long as $0\leq c\leq 1$.*

Proof. $a(a+b)>0$ is equivalent to $a+b<0$ if $a<0$ and $a+b>0$ if $a>0$.

Suppose $a<0$ and $a+b<0$. Note that $a+cb=a+b+(c-1)b$. If $b\geq 0$, then $(c-1)b\leq 0$ and thus $a+cb\leq a+b<0$. If $b<0$, then by $a<0$ and $c\geq 0$, $a+cb<0$. Therefore $a(a+cb)>0$.

Suppose $a>0$ and $a+b>0$. If $b\leq 0$, then $(c-1)b\geq 0$ and therefore $a+cb\geq a+b>0$. If $b>0$, then by $a>0$ and $c\geq 0$, $a+cb>0$. Therefore $a(a+cb)>0$. □

Lemma 2. *For $\Delta e,\Delta f,M,\theta\in\mathbb{R}^+$, if $M-\Delta f-\Delta e\geq 0$, $\frac{\sum_{s=0}^{n}(\Delta e)^s(\Delta f)^{n-s}}{M^n}$ is non-increasing in $n\in\mathbb{N}^+$.*

Proof. $\frac{\sum_{s=0}^{n}(\Delta e)^s(\Delta f)^{n-s}}{M^n}$ is non-increasing in $n\in\mathbb{N}^+$ if $\frac{\sum_{s=0}^{n}(\Delta e)^s(\Delta f)^{n-s}}{M^n}-\frac{\sum_{s=0}^{n+1}(\Delta e)^s(\Delta f)^{n+1-s}}{M^{n+1}}\geq 0$ for $n\in\mathbb{N}^+$.

Now

$$
\begin{aligned}
&\frac{\sum_{s=0}^{n}(\Delta e)^{s}(\Delta f)^{n-s}}{M^{n}}-\frac{\sum_{s=0}^{n+1}(\Delta e)^{s}(\Delta f)^{n+1-s}}{M^{n+1}}\\
&=\frac{\sum_{s=0}^{n}(\Delta e)^{s}(\Delta f)^{n-s}}{M^{n}}-\frac{\sum_{s=0}^{n}(\Delta e)^{s}(\Delta f)^{n-s}+\frac{(\Delta e)^{n+1}}{\Delta f}}{M^{n}}\frac{\Delta f}{M}\\
&=\frac{\sum_{s=0}^{n}(\Delta e)^{s}(\Delta f)^{n-s}}{M^{n}}\left(1-\frac{\Delta f}{M}\right)-\frac{\frac{(\Delta e)^{n+1}}{\Delta f}}{M^{n}}\frac{\Delta f}{M}\\
&=\frac{1}{M^{n+1}}\left[\sum_{s=0}^{n}(\Delta e)^{s}(\Delta f)^{n-s}(M-\Delta f)-(\Delta e)^{n+1}\right]\\
&=\frac{(\Delta e)^{n}}{M^{n+1}}\left[\sum_{s=0}^{n}\left(\frac{\Delta f}{\Delta e}\right)^{n-s}(M-\Delta f)-\Delta e\right]\\
&=\frac{(\Delta e)^{n}(M-\Delta f)}{M^{n+1}}\left[\sum_{s=0}^{n}\left(\frac{\Delta f}{\Delta e}\right)^{n-s}-\frac{\Delta e}{M-\Delta f}\right]\\
&=\frac{(\Delta e)^{n}(M-\Delta f)}{M^{n+1}}\left[\sum_{s=0}^{n-1}\left(\frac{\Delta f}{\Delta e}\right)^{n-s}+1-\frac{\Delta e}{M-\Delta f}\right]\\
&=\frac{(\Delta e)^{n}(M-\Delta f)}{M^{n+1}}\left[\sum_{s=0}^{n-1}\left(\frac{\Delta f}{\Delta e}\right)^{n-s}+\frac{M-\Delta f-\Delta e}{M-\Delta f}\right]\\
&\geq\frac{(\Delta e)^{n}(M-\Delta f)}{M^{n+1}}\left[\sum_{s=0}^{n-1}\left(\frac{\Delta f}{\Delta e}\right)^{n-s}\right]\\
&\geq 0
\end{aligned}
$$

where the first inequality holds because $M-\Delta f-\Delta e\geq 0$ and $\Delta e>0$. □

Lemma 3. *For $\Delta e,\Delta f,M,\theta\in\mathbb{R}^{+}$, if $M-\Delta f-\Delta e\geq 0$ and the preference u is monotonic with $u_H<0$,*

$$
u_{H}e^{-\theta t}+\frac{1}{2}u_{HH}(\Delta f+\Delta e)\left(e^{-\theta t}\right)^{2}+\cdots+\frac{1}{n!}\frac{\partial^{n}u}{\partial H^{n}}\left(\sum_{s=0}^{n-1}(\Delta e)^{s}(\Delta f)^{n-s}\right)\left(e^{-\theta t}\right)^{n}+\cdots<0
$$

.

Proof. By monotonicity of preference and $u_H<0$, for $M>0$ I have

$$
u(C,H+M)-u(C,H)=u_{H}M+\frac{1}{2}u_{HH}M^{2}+\cdots+\frac{1}{n!}\frac{\partial^{n}u}{\partial H^{n}}M^{n}+\cdots<0
$$

. Since $0 \leq \frac{(\Delta f+\Delta e)}{M} e^{-\theta t} \leq 1$ for $t \in \mathbb{N}^{+}$, by Lemma 1

$$u_H M + \frac{\Delta f + \Delta e}{M} e^{-\theta t} \left[\frac{1}{2} u_{HH} M^2 + \cdots + \frac{1}{n!} \frac{\partial^n u}{\partial H^n} M^n + \cdots \right] < 0$$

. By Lemma 2,

$$\frac{\frac{\sum_{s=0}^{2} (\Delta e)^s (\Delta f)^{2-s}}{M^2} \left(e^{-\theta t}\right)^2}{\frac{(\Delta f+\Delta e)}{M} e^{-\theta t}} = \frac{\frac{\sum_{s=0}^{2} (\Delta e)^s (\Delta f)^{2-s}}{M^2}}{\frac{(\Delta f+\Delta e)}{M}} e^{-\theta t} \leq 1$$

. Apply Lemma 1 again to get

$$\begin{aligned}
& u_H M + \frac{1}{2} u_{HH} M^2 \frac{\Delta f + \Delta e}{M} e^{-\theta t} \\
& + \frac{\frac{\sum_{s=0}^{2} (\Delta e)^s (\Delta f)^{2-s}}{M^2}}{\frac{(\Delta f+\Delta e)}{M}} e^{-\theta t} \frac{(\Delta f + \Delta e)}{M} e^{-\theta t} \left[\frac{1}{3!} u_{HHH} M^3 + \cdots + \frac{1}{n!} \frac{\partial^n u}{\partial H^n} M^n + \cdots \right] \\
= & u_H M + \frac{1}{2} u_{HH} M^2 \frac{\Delta f + \Delta e}{M} e^{-\theta t} \\
& + \frac{\sum_{s=0}^{2} (\Delta e)^s (\Delta f)^{2-s}}{M^2} \left(e^{-\theta t}\right)^2 \left[\frac{1}{3!} u_{HHH} M^3 + \cdots + \frac{1}{n!} \frac{\partial^n u}{\partial H^n} M^n + \cdots \right] \\
< & 0
\end{aligned}$$

Repeating this process for all other $n \in \mathbb{N}^{+}$, I finally get

$$u_H e^{-\theta t} + \frac{1}{2} u_{HH} \left(e^{-\theta t}\right)^2 (\Delta f + \Delta e) + \cdots + \frac{1}{n!} \frac{\partial^n u}{\partial H^n} \left(\sum_{s=0}^{n-1} (\Delta e)^s (\Delta f)^{n-s} \right) \left(e^{-\theta t}\right)^n + \cdots < 0$$

. □

D.2 Proof of Proposition 1

Proof. Let $\Delta a = \Delta C_{U1}$ and $\Delta b = \Delta C_{U2}$.

θ is habit depreciation rate implies $\theta \in \mathbb{R}^{+}$. Taking $M = \$5000$, then $M - \Delta a - \left(1 - e^{-\theta}\right) \Delta b > 0$ in all the questions for habit depreciation rate.[59]

[59] See Table 29 for all the values of ΔC_{U1} and ΔC_{U2} for this module.

A respondent prefers Universe One for a better future experience if

$$
\begin{aligned}
&\int_0^\infty e^{-\rho t}\left[u_H e^{-\theta t}\Delta a+\frac{1}{2}u_{HH}\left(e^{-\theta t}\Delta a\right)^2+\cdots\right]dt\\
&-\int_0^\infty e^{-\rho t}\left[u_H e^{-\theta t}\left(1-e^{-\theta}\right)\Delta b+\frac{1}{2}u_{HH}\left(e^{-\theta t}\left(1-e^{-\theta}\right)\Delta b\right)^2+\cdots\right]dt\\
=&\int_0^\infty e^{-\rho t}\left[u_H e^{-\theta t}\left[\Delta a-\left(1-e^{-\theta}\right)\Delta b\right]+\frac{1}{2}u_{HH}\left(e^{-\theta t}\right)^2\left[(\Delta a)^2-\left(\left(1-e^{-\theta}\right)\Delta b\right)^2\right]+\cdots\right]dt\\
=&\left[\Delta a-\left(1-e^{-\theta}\right)\Delta b\right]\int_0^\infty e^{-\rho t}\left[u_H e^{-\theta t}+\frac{1}{2}u_{HH}\left(e^{-\theta t}\right)^2\left[\Delta a+\left(1-e^{-\theta}\right)\Delta b\right]+\cdots\right]dt\\
>&0
\end{aligned}
$$

which, by Lemma 3, would be true if

$$\Delta a-\left(1-e^{-\theta}\right)\Delta b<0$$

or

$$\theta>-\ln\left(1-\frac{\Delta a}{\Delta b}\right)$$

. □

D.3 Proof of Proposition 2

Proof.

$$\frac{u_{CH}}{u_{HH}}\frac{u_H}{u_C}=\frac{-\gamma v''}{\gamma^2 v''}\frac{-\gamma v'}{v'}=1$$

, and

$$\frac{u_{CH}}{u_{CC}}\frac{u_C}{u_H}=\frac{-\gamma v''}{v''}\frac{v'}{-\gamma v'}=1$$

. □

D.4 Proof of Proposition 3

Proof.

$$
\begin{aligned}
\frac{Hu_Hu_{CH}}{u_C\left(u_H+Hu_{HH}\right)}&=\frac{H\left(-\gamma\frac{C}{H^{\gamma+1}}v'\right)\left(-\gamma\frac{1}{H^{\gamma+1}}v'-\gamma\frac{C}{H^{2\gamma+1}}v''\right)}{\frac{1}{H^\gamma}v'\left\{-\gamma\frac{C}{H^{\gamma+1}}v'+H\gamma\frac{C}{H^2}\left[(\gamma+1)\frac{1}{H^\gamma}v'+\gamma\frac{C}{H^{2\gamma}}v''\right]\right\}}\\
&=1
\end{aligned}
$$

, and

$$\frac{Cu_C u_{CH}}{u_H\left(u_C + Cu_{CC}\right)} = \frac{C\frac{1}{H^\gamma}v'\left(-\gamma\frac{1}{H^{\gamma+1}}v' - \gamma\frac{C}{H^{2\gamma+1}}v''\right)}{\left(-\gamma\frac{C}{H^{\gamma+1}}v'\right)\left(\frac{1}{H^\gamma}v' + C\frac{1}{H^{2\gamma}}v''\right)}$$
$$= 1$$

. □

D.5 Proof of Proposition 4

Proof. Under second-order elicitation, a respondent prefers Universe One for a better future experience if

$$\frac{1}{\rho}\left\{u_C\Delta f + \frac{1}{\rho+\theta}u_H\left(\rho\Delta e + \theta\Delta f\right) + \frac{1}{2}\left[u_{CC}\left(\Delta f\right)^2 + 2\frac{1}{\rho+\theta}u_{CH}\Delta f\left(\rho\Delta e + \theta\Delta f\right)\right.\right.$$
$$\left.\left. + \frac{1}{(\rho+\theta)(\rho+2\theta)}u_{HH}\left(\rho\left(\rho+\theta\right)\left(\Delta e\right)^2 + 2\rho\theta\Delta e\Delta f + 2\theta^2\left(\Delta f\right)^2\right)^2\right]\right\}$$
$$-\frac{1}{\rho}\left\{u_C\left(-\Delta f\right) + \frac{1}{\rho+\theta}u_H\left(\rho\left(-\Delta e\right) + \theta\left(-\Delta f\right)\right) + \frac{1}{2}\left[u_{CC}\left(\Delta f\right)^2 + 2\frac{1}{\rho+\theta}u_{CH}\Delta f\left(\rho\Delta e + \theta\Delta f\right)\right.\right.$$
$$\left.\left. + \frac{1}{(\rho+\theta)(\rho+2\theta)}u_{HH}\left(\rho\left(\rho+\theta\right)\left(\Delta e\right)^2 + 2\rho\theta\Delta e\Delta f + 2\theta^2\left(\Delta f\right)^2\right)^2\right]\right\}$$
$$= \frac{2}{\rho}\left[u_C\Delta f + \frac{1}{\rho+\theta}u_H\left(\rho\Delta e + \theta\Delta f\right)\right]$$
$$> 0$$

which, by $u_C > 0$, would be true if

$$-\frac{u_H}{u_C} < \frac{(\rho+\theta)\Delta f}{\rho\Delta e + \theta\Delta f}$$

. □

D.6 Proof of Proposition 5

Proof. Under second-order elicitation, a respondent prefers Universe One for a better future experience if

$$
\begin{aligned}
&\frac{1}{2}\left[\frac{1}{\rho+\theta}u_H\left(-\Delta f\right)+\frac{1}{2}\frac{1}{\rho+2\theta}u_{HH}\left(\Delta f\right)^2\right]+\frac{1}{2}\left[\frac{1}{\rho+\theta}u_H\Delta e+\frac{1}{2}\frac{1}{\rho+2\theta}u_{HH}\left(\Delta e\right)^2\right]\\
&=\frac{1}{2}\left\{\frac{1}{\rho+\theta}u_H\left(\Delta e-\Delta f\right)+\frac{1}{2}\frac{1}{\rho+2\theta}u_{HH}\left[\left(\Delta f\right)^2+\left(\Delta e\right)^2\right]\right\}\\
&>0
\end{aligned}
$$

which, by $u_H < 0$,[60] would be true if

$$\frac{Hu_{HH}}{u_H} < \frac{2\left(\rho+2\theta\right)}{\rho+\theta}\frac{\Delta f/\Delta e-1}{\left(\Delta f/\Delta e\right)^2+1}\frac{H}{\Delta e}$$

. □

[60] This sign is elicited in the existence of habit formation question.

D.7 Proof of Proposition 6

Proof. Under third-order elicitation, a respondent prefers Universe One for a better future experience if

$$
\begin{aligned}
&\frac{1}{2}\frac{1}{\rho}\left\{u_C\Delta f+\frac{1}{\rho+\theta}u_H\left(\rho\Delta e+\theta\Delta f\right)+\frac{1}{2}\left[u_{CC}\left(\Delta f\right)^2+2\frac{1}{\rho+\theta}u_{CH}\Delta f\left(\rho\Delta e+\theta\Delta f\right)\right.\right.\\
&\left.\left.+\frac{1}{\left(\rho+\theta\right)\left(\rho+2\theta\right)}u_{HH}\left(\rho\left(\rho+\theta\right)\left(\Delta e\right)^2+2\rho\theta\Delta e\Delta f+2\theta^2\left(\Delta f\right)^2\right)\right]\right\}\\
&\frac{1}{2}\frac{1}{\rho}\left\{-u_C\Delta f-\frac{1}{\rho+\theta}u_H\left(\rho\Delta e+\theta\Delta f\right)+\frac{1}{2}\left[u_{CC}\left(\Delta f\right)^2+2\frac{1}{\rho+\theta}u_{CH}\Delta f\left(\rho\Delta e+\theta\Delta f\right)\right.\right.\\
&\left.\left.+\frac{1}{\left(\rho+\theta\right)\left(\rho+2\theta\right)}u_{HH}\left(\rho\left(\rho+\theta\right)\left(\Delta e\right)^2+2\rho\theta\Delta e\Delta f+2\theta^2\left(\Delta f\right)^2\right)\right]\right\}\\
&-\frac{1}{2}\frac{1}{\rho}\left\{\left[u_C+\frac{\theta}{\rho+\theta}u_H\right]\Delta f+\frac{1}{2}\left[u_{CC}+2u_{CH}\frac{\theta}{\rho+\theta}+u_{HH}\frac{2\theta^2}{\left(\rho+\theta\right)\left(\rho+2\theta\right)}\right]\left(\Delta f\right)^2\right\}\\
&-\frac{1}{2}\frac{1}{\rho}\left\{\left[u_C+\frac{\theta}{\rho+\theta}u_H\right]\left(-\Delta f\right)+\frac{1}{2}\left[u_{CC}+2u_{CH}\frac{\theta}{\rho+\theta}+u_{HH}\frac{2\theta^2}{\left(\rho+\theta\right)\left(\rho+2\theta\right)}\right]\left(\Delta f\right)^2\right\}\\
=&\frac{1}{2}\frac{1}{\rho}\left[u_{CC}\left(\Delta f\right)^2+2\frac{1}{\rho+\theta}u_{CH}\Delta f\left(\rho\Delta e+\theta\Delta f\right)\right.\\
&\left.+\frac{1}{\left(\rho+\theta\right)\left(\rho+2\theta\right)}u_{HH}\left(\rho\left(\rho+\theta\right)\left(\Delta e\right)^2+2\rho\theta\Delta e\Delta f+2\theta^2\left(\Delta f\right)^2\right)\right]\\
&-\frac{1}{2}\frac{1}{\rho}\left[u_{CC}+2u_{CH}\frac{\theta}{\rho+\theta}+u_{HH}\frac{2\theta^2}{\left(\rho+\theta\right)\left(\rho+2\theta\right)}\right]\left(\Delta f\right)^2\\
=&\frac{1}{2}\frac{1}{\rho}\left[2u_{CH}\frac{\rho}{\rho+\theta}\Delta f\Delta e+\frac{1}{\left(\rho+\theta\right)\left(\rho+2\theta\right)}u_{HH}\left(\rho\left(\rho+\theta\right)\left(\Delta e\right)^2+2\rho\theta\Delta e\Delta f\right)\right]\\
>&0
\end{aligned}
$$

which, by $u_{HH} < 0$,[61] would be true if

$$\frac{u_{CH}}{u_{HH}} < -\frac{\left(\rho+\theta\right)\Delta e+2\theta\Delta f}{2\left(\rho+2\theta\right)\Delta f}$$

. □

[61] This sign is elicited in the Hu_{HH}/u_H question.

D.8 Proof of Proposition 7

Proof. Under third-order elicitation, a respondent prefers Universe One for a better future experience if

$$\begin{aligned}
&\frac{1}{2}\frac{1}{\rho}\left\{\left[u_C+\frac{\theta}{\rho+\theta}u_H\right]\Delta f+\frac{1}{2}\left[u_{CC}+2u_{CH}\frac{\theta}{\rho+\theta}+u_{HH}\frac{2\theta^2}{(\rho+\theta)(\rho+2\theta)}\right](\Delta f)^2\right\}\\
&+\frac{1}{2}\frac{1}{\rho}\left\{\left[u_C+\frac{\theta}{\rho+\theta}u_H\right](-\Delta f)+\frac{1}{2}\left[u_{CC}+2u_{CH}\frac{\theta}{\rho+\theta}+u_{HH}\frac{2\theta^2}{(\rho+\theta)(\rho+2\theta)}\right](\Delta f)^2\right\}\\
&-\frac{1}{2}\left[\frac{1}{\rho+\theta}u_H\Delta e+\frac{1}{2}\frac{1}{\rho+2\theta}u_{HH}(\Delta e)^2\right]-\frac{1}{2}\left[\frac{1}{\rho+\theta}u_H(-\Delta e)+\frac{1}{2}\frac{1}{\rho+2\theta}u_{HH}(\Delta e)^2\right]\\
=&\frac{1}{2}\frac{1}{\rho}\left[u_{CC}+2u_{CH}\frac{\theta}{\rho+\theta}+u_{HH}\frac{2\theta^2}{(\rho+\theta)(\rho+2\theta)}\right](\Delta f)^2-\frac{1}{2}\frac{1}{\rho+2\theta}u_{HH}(\Delta e)^2\\
>&0
\end{aligned}$$

which, by $u_{HH}<0$,[62] would be true if

$$\frac{u_{CC}}{u_{HH}}<\frac{\rho}{\rho+2\theta}\left(\frac{\Delta e}{\Delta f}\right)^2-\frac{2\theta}{\rho+\theta}\frac{u_{CH}}{u_{HH}}-\frac{2\theta^2}{(\rho+\theta)(\rho+2\theta)}$$

. □

D.9 Proof of Proposition 8

Proof. Choosing Universe One over Universe Two if

$$u(C,H(\Delta C>0,\Delta C_{others}=0))>u(C,H(\Delta C=0,\Delta C_{others}>0))$$

. Subtracting the baseline utility from both sides to get

$$\begin{aligned}
&u(C,H(\Delta C=0,\Delta C_{others}>0))-u(C,H(\Delta C=0,\Delta C_{others}=0))\\
&<u(C,H(\Delta C>0,\Delta C_{others}=0))-u(C,H(\Delta C=0,\Delta C_{others}=0))\\
&<0
\end{aligned}$$

where the last inequality because of the existence of internal habit. □

[62] This sign is elicited in the Hu_{HH}/u_H question.

D.10 Proof of Proposition 9

Proof. Let $\Delta a = \Delta C$ and $\Delta b = \Delta C_{others}$.

Take $M = \$5000$, then $M - (1-\omega)\Delta C - \omega \Delta C_{others} > 0$ in all the questions for external habit.

A respondent prefers Universe One for a better future experience if

$$
\begin{aligned}
&\int_0^\infty e^{-\rho t}\left[u_H e^{-\theta t}\left((1-\omega)\Delta C\right) + \frac{1}{2}u_{HH}\left(e^{-\theta t}\left((1-\omega)\Delta C\right)\right)^2 + \cdots\right]dt \\
&-\int_0^\infty e^{-\rho t}\left[u_H e^{-\theta t}\left(\omega \Delta C_{others}\right) + \frac{1}{2}u_{HH}\left(e^{-\theta t}\left(\omega \Delta C_{others}\right)\right)^2 + \cdots\right]dt \\
=&\left[(1-\omega)\Delta C - \omega \Delta C_{others}\right]\int_0^\infty e^{-\rho t}\left[u_H e^{-\theta t} + \frac{1}{2}u_{HH}\left(e^{-\theta t}\right)^2\left(\left((1-\omega)\Delta C + \omega \Delta C_{others}\right)\right) + \cdots\right]dt \\
>&0
\end{aligned}
$$

which, by Lemma 3, would be true if

$$(1-\omega)\Delta C - \omega \Delta C_{others} < 0$$

or

$$\omega > \frac{\Delta C}{\Delta C + \Delta C_{others}}$$

. □

D.11 Proof of Proposition 10

Proof. Under first-order elicitation, a respondent prefers Universe One for a better future experience if

$$\frac{1}{\rho}\left[u_{C_{others}} + \frac{\theta\omega}{\rho+\theta}u_H\right]\Delta C^{U1}_{others} - \frac{\omega}{\rho+\theta}u_H \Delta C^{U2}_{others} > 0$$

which, by $u_H < 0$,[63] would be true if

$$\frac{u_{C_{others}}}{u_H} < \frac{\omega}{\rho+\theta}\left(\rho\frac{\Delta C^{U2}_{others}}{\Delta C^{U1}_{others}} - \theta\right)$$

. □

[63]This sign is elicited in the existence of habit formation question.

D.12 Proof of Proposition 12

Proof. Let

$$\begin{aligned}
Q(a) \equiv \int_0^1 e^{-\rho t} \Big\{ & u_C a + \frac{1}{2} u_{CC} a^2 + u_{CH} \left(\Delta c \left(1 - e^{-\theta t} \right) a \right) + \cdots \\
& + \left[u_H \left(1 - e^{-\theta t} \right) a + \frac{1}{2} u_{HH} \left(\left(1 - e^{-\theta t} \right) a \right)^2 + \cdots \right] \Big\} dt \\
& + \int_1^\infty e^{-\rho t} \left[u_H e^{-\theta t} \left(1 - e^{-\theta} \right) a + \frac{1}{2} u_{HH} \left(e^{-\theta t} \left(1 - e^{-\theta} \right) a \right)^2 + \cdots \right] dt
\end{aligned}$$

.

Under exact elicitation, a respondent prefers Universe One for a better future experience if

$$\begin{aligned}
Q(\Delta e) - e^{-\rho} Q(\Delta f) &= \Delta e \frac{Q(\Delta e)}{\Delta e} - e^{-\rho} \Delta f \frac{Q(\Delta f)}{\Delta f} \\
&> \left(\Delta e - e^{-\rho} \Delta d \right) \frac{Q(\Delta e)}{\Delta e} \\
&> 0
\end{aligned}$$

where first inequality holds because by diminishing marginal utility $\frac{Q1(\Delta e)}{\Delta e} > \frac{Q1(\Delta f)}{\Delta f} > 0$ for $\Delta f > \Delta e > 0$. This would be true if

$$\Delta e - e^{-\rho} \Delta f > 0$$

or equivalently

$$\rho > -\ln \frac{\Delta e}{\Delta f}$$

. □

E Response Frequency

See Table 28.

F Survey

F.1 Instructions

Instruction 1/2

The survey starts with an instruction that specifies the hypothetical situation as detailed in section 2.2. A set of practice questions follows to test the respondents' understanding of the hypothetical situation:

Table 28: Response Frequency (Percentage) - Preference Parameters Identifiable to Scale

Question	Wave	Choice					
		1	2	3	4	5	6
Habit Depreciation Rate	1	28	10	16	11	7	28
	2	30	10	14	11	6	30
Slope of Indifference Curve	1	32	3	7	7	12	39
	2	31	4	6	2	20	36
Hu_{HH}/u_H	1	14	4	8	10	3	60
	2	25	2	6	5	1	61
u_{CH}/u_{HH}	1	7	4	11	10	27	41
	2	9	3	10	9	34	36
u_{CC}/u_{HH}	1	24	30	10	9	5	22
	2	24	19	8	10	9	30
External Habit Mixture Coefficient	1	46	9	13	8	4	18
	2	46	4	7	16	5	23
$u_{C_{others}}/u_H$	1	26	18	10	8	2	36
	2	24	19	8	6	3	40
Time Discount Rate	1	34	4	7	7	4	43
	2	39	3	5	5	4	45

With no inflation and prices of everything staying the same, if you can buy 3 bananas with one dollar in the last year, how many bananas can you buy with one dollar in the next year?

- 5
- 3
- 1
- No idea

If you rent the durable goods you consume, select any of the following that you own (that is, not rent):

- Residence
- Car
- Furniture
- I do not own any of the above
- No idea

Instruction 2/2

After passing the practice questions, the respondents are presented with an instruction on how to read monthly spending graphs.

In this survey, you'll compare your experience in several universes that are identical except that your monthly spending differs.

- Monthly spending refers to the total amount of money you spend, rather than earn, in each month.
- You will be asked to find out in which universe you will have (had) a better experience given how much you spend (spent).
- 'Better' means more satisfying.
- You can afford the monthly spending specified in the questions.

The difference of your monthly spending between the universes is detailed in monthly spending graphs, like the one below.

Now let's learn to read a monthly spending graph.

The first element of a monthly spending graph is the timeline, with past on the left, now in the middle, future on the right. A thick vertical line representing now separates the past from the future.

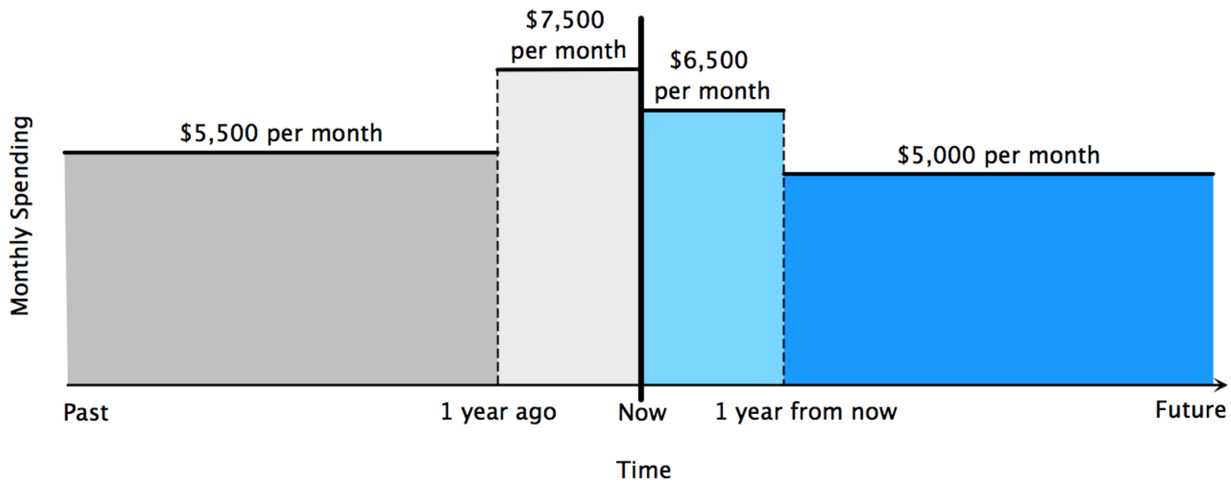

Figure 23: Instruction - Monthly Spending Graph 1

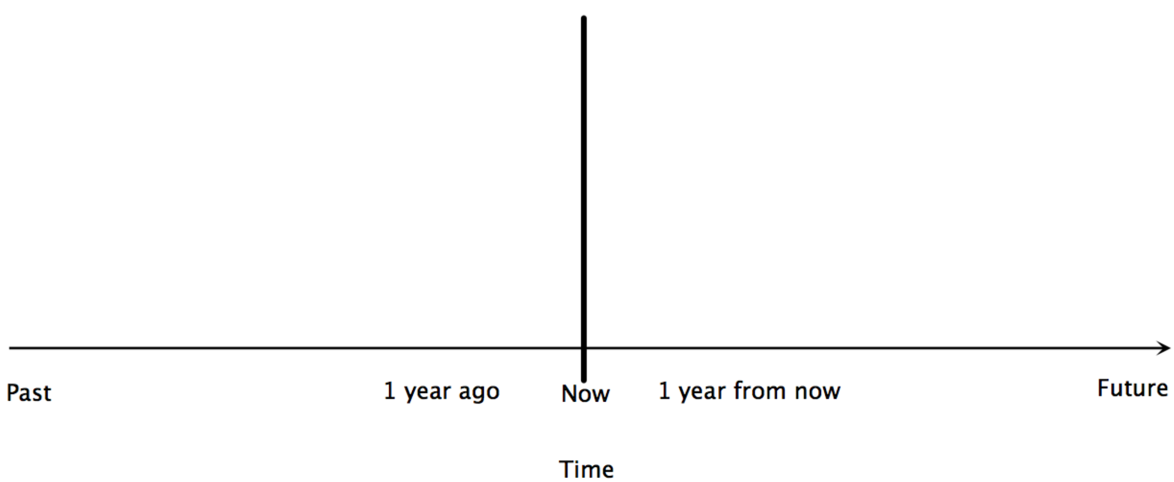

Figure 24: Instruction - Timeline

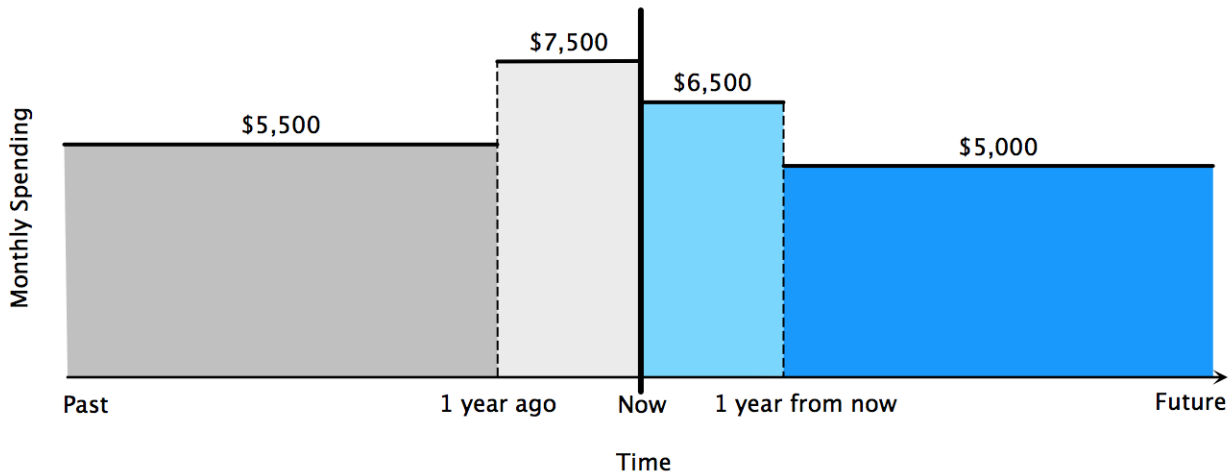

Figure 25: Instruction - Monthly Spending Graph 2

To fix the idea, the ‘Past’ means as far back in the past as you can remember and the ‘Future’ as far in the future as you can imagine. If easier, think of the ‘Past’ as the past 30 years and the ‘Future’ as the next 30 years.

The second element of a monthly spending graph is the bars above the timeline.

- The height of bars represents the level of monthly spending (again, not income) in time frames covered by the bars.
- The exact level of monthly spending is labeled on top of the corresponding bar. The words ’per month’ are saved for space consideration from now on, but you should always remember that the numbers are per month spending.
- The bars are colored differently to help you distinguish different time frames.

For example, if the following monthly spending graph describes your monthly spending,

you spent/spend

- $5,500 per month in the ’past’ until ’1 year ago’;
- $7,500 per month from ’1 year ago’ until ’now’ (or in the ’past year’);
- $6,500 per month from ’now’ to ’1 year from now’ (or in the ’next year’);
- $5,000 per month from ’1 year from now’ onward.

To highlight the difference of monthly spending, the time frames as in the above example are sometimes collapsed into three or two timeframes. For instance, if in Universe One your monthly spending graph is

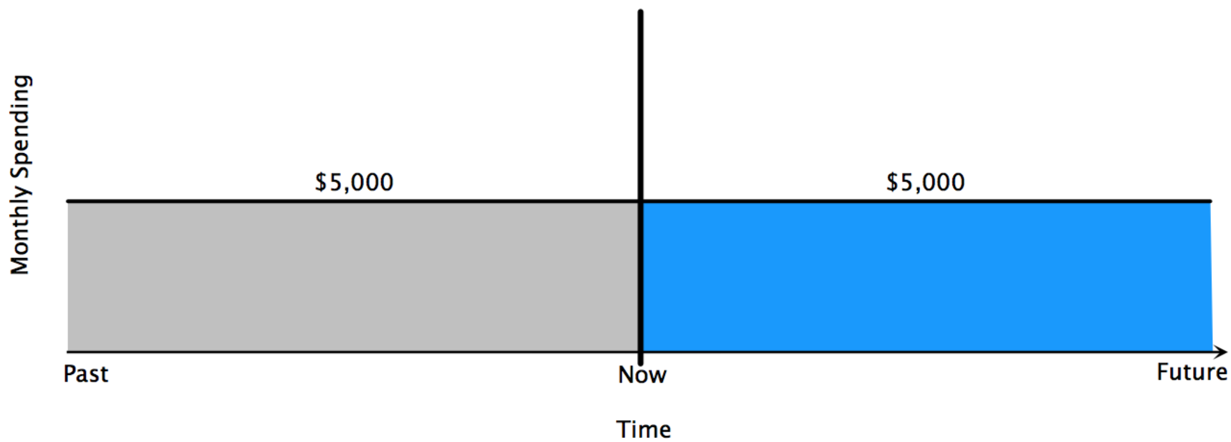

Figure 26: Instruction - Monthly Spending Graph 3

while in Universe Two your monthly spending is

then the difference and the similarity of your monthly spending in the two universes are that

- in Universe Two you spent $1,000 more per month in the 'past' than you did in Universe One where you spent $5,000 per month in the 'past'; and
- in both universes, you will spend $5,000 per month from 'now' onward.

Then, the respondents are presented with a set of practice questions testing their understanding of the above instruction.

Imagine that your monthly spending is detailed in the following monthly spending graph

How much will you spend per month in the next year?

- $5,000
- $6,000
- $6,500
- $8,000

How much did you spend per month from 'as far back as you can remember in the past' until '1 year ago'?

- $5,000

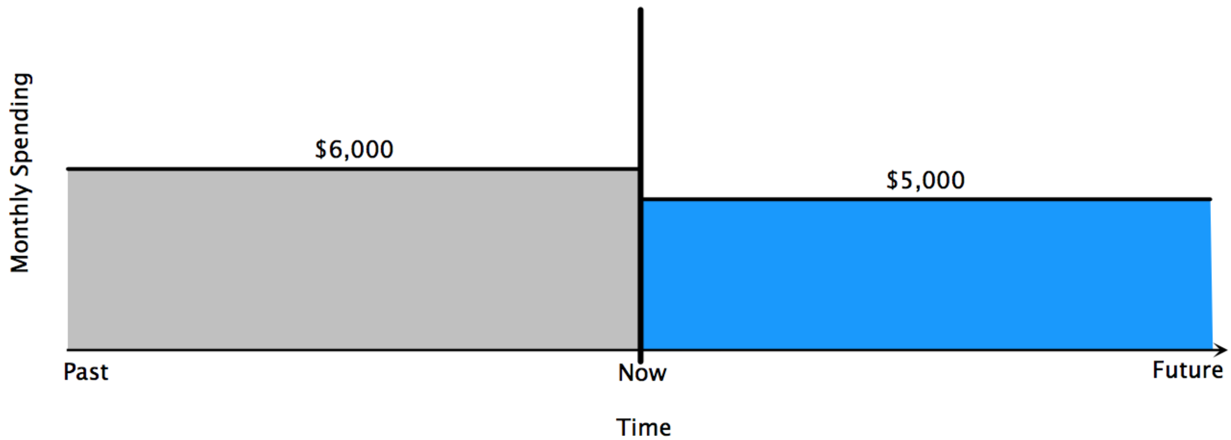

Figure 27: Instruction - Monthly Spending Graph 4

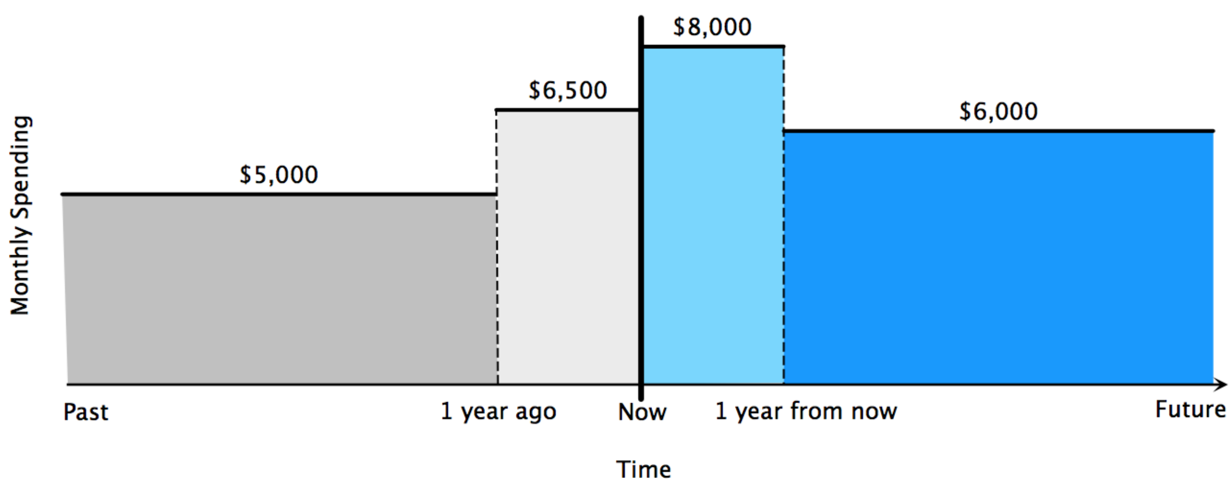

Figure 28: Instruction - Monthly Spending Graph 5

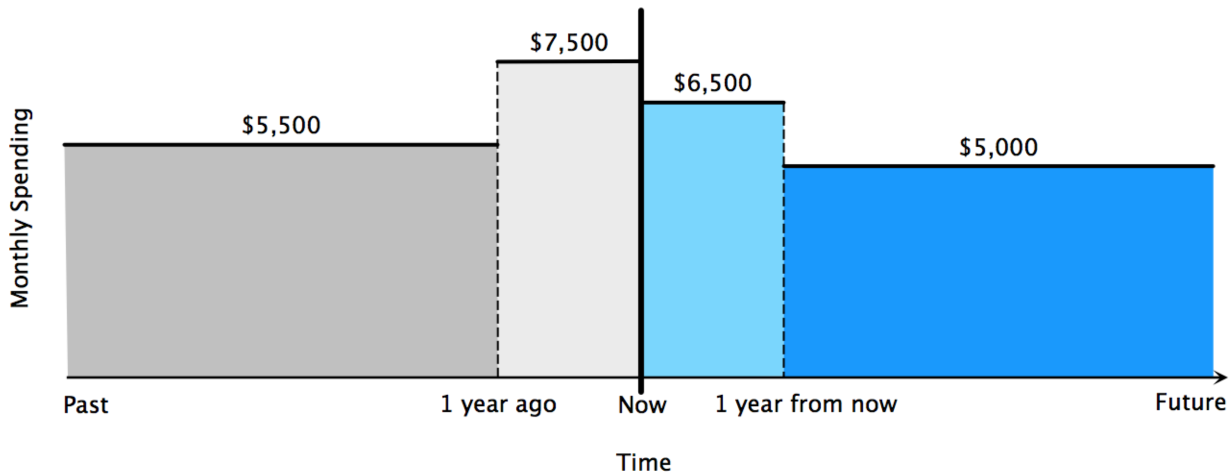

Figure 29: Instruction - Monthly Spending Graph 2

    - $6,000
    - $6,500
    - $8,000

- Imagine that your monthly spending in Universe One and Universe Two are detailed in the following monthly spending graphs.
- [The graphs are in the choices below. You can directly click the graph to give your answer.]

  In which universe did you spend more per month in the 'past year'?

    - Universe One
    - Universe Two

  In which universe will you spend more per month from '1 year from now' onward?

    - Universe One
    - Universe Two

  In the graphs of last question, how much more did you spend in Universe One than in Universe Two from 'as far back in the past as you can remember' until '1 year ago'?

    - $0
    - $500
    - $1,000
    - $5,500

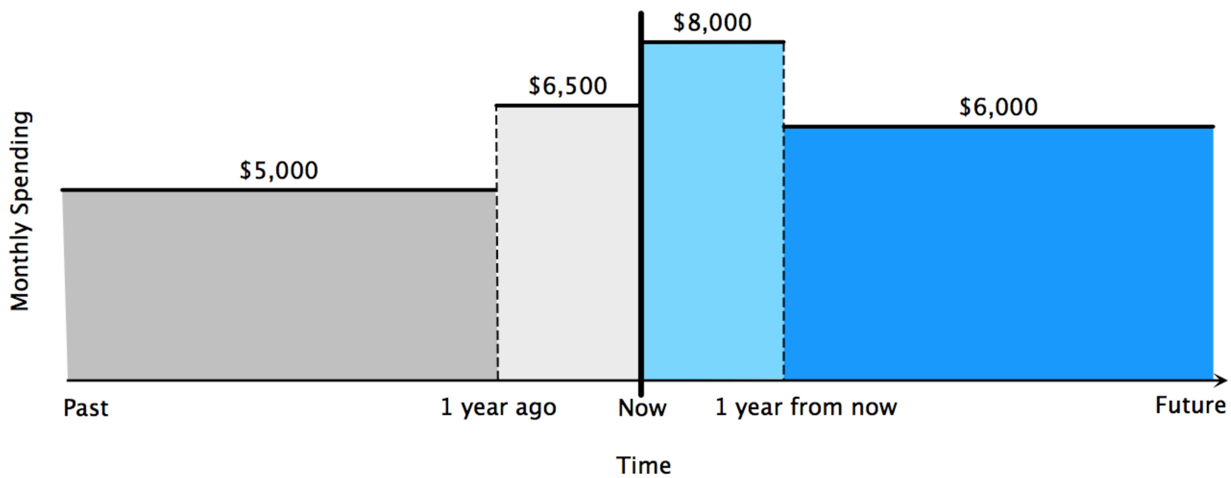

Figure 30: Instruction - Monthly Spending Graph 5

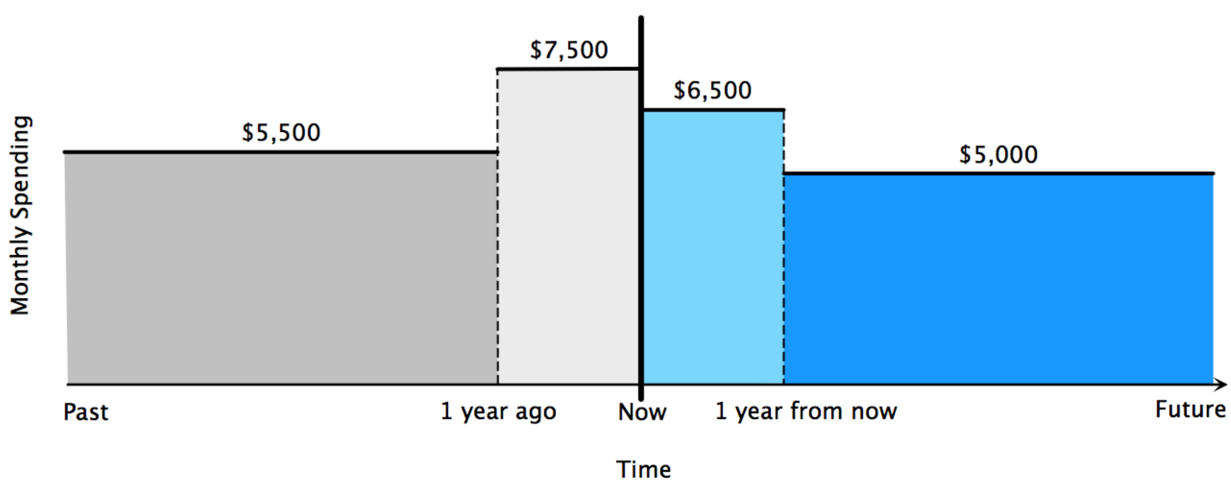

Figure 31: Instruction - Monthly Spending Graph 2

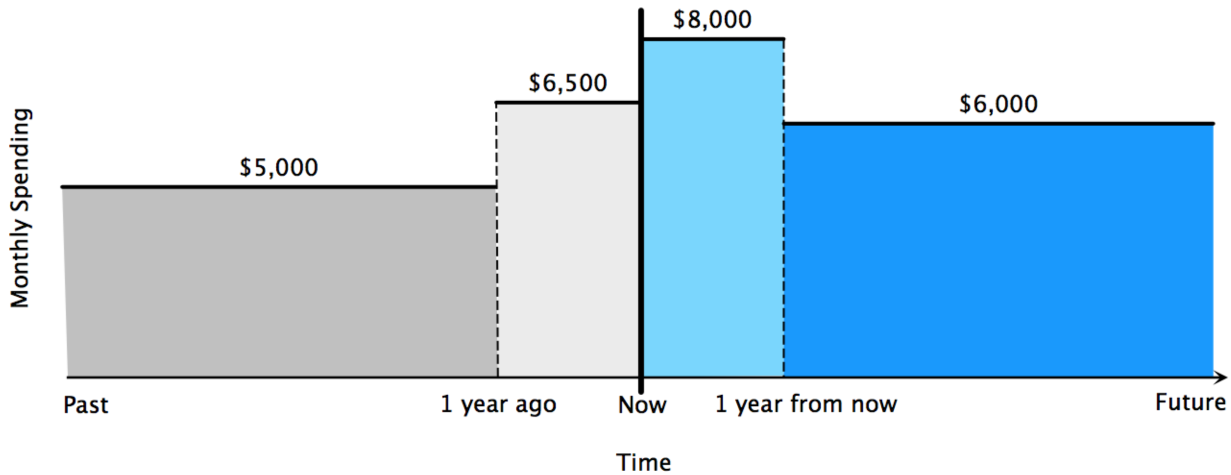

Figure 32: Instruction - Monthly Spending Graph 5

Final Instruction

A final instruction preempts the respondents on the seemingly repetitiveness of follow-up questions and encourages efforts with attention checks and a potential bonus reward. An opportunity to review the instructions is also presented.

> We designed the survey to learn as much as possible from your answers. To increase the power of the study result, each question is normally followed by additional questions that vary slightly from previous questions. Although the survey may look repetitive, please pay careful attention and answer each question the best you can.
>
> Implicit and explicit attention checks are integrated into this survey. Responses show signs of inattentiveness will be rejected. A small lottery ($1) will be randomly paid as a bonus to workers who show excellence in the responses. The chance to get this lottery reward is 1 in 100. Your normal HIT payment won't be affected by this lottery.
>
> If you would like to view these instructions again before beginning the survey, please check the following box.
>
> ☐ View Instructions Again

F.2 Core Modules

The survey has nine core modules each corresponding to one or two preference parameters of interest.

The flow of each core module is

1. ask the respondent to choose which universe brings her a better past experience (Figure 2);
2. ask the respondent to choose which universe brings her a better future experience (Figure 3);
3. present the respondent with a set of follow-up monthly spending graphs that varies slightly from the original set and go back to step 1. The total number of sets of follow-up questions ranges from 1 to 2 (Figure 7).

The main element of the survey questions in the core modules are the monthly spending graphs which are in the main text. To save space, they are not repeated here. In the following, we present the changes between follow-up questions and initial questions in terms of the quantities that are necessary to elicit the preference parameters in Propositions 1, 4-10, 12.

F.3 End-of-Survey Check of Understanding of the Hypothetical Situation

At the end of the survey, I check the respondents' understanding of the hypothetical situation again using the following questions, which serves as an implicit attention check.

> Under the hypothetical situation of this survey, if you can buy 3 bananas with one dollar in the last year, how many bananas can you buy with one dollar in the next year?
>
> - 5
> - 3
> - 1
> - No idea
>
> Under the hypothetical situation of this survey, select any of the following that you own (that is, not rent):
>
> - Residence
> - Car
> - Furniture
> - I do not own any of the above
> - No idea
>
> Under the hypothetical situation of this survey, do things you want change over time?
>
> - Yes
> - Maybe

Table 29: Quantities in Monthly Spending Graphs

		2nd follow-up question	1st follow-up question	Initial question	1st follow-up question	2nd follow-up question
		if choosing U2 in both initial and 1st follow-up questions	if choosing U2 in initial question		if choosing U1 in initial question	if choosing U1 in both initial and 1st follow-up questions
Habit Depreciation	ΔC_{U1}	400	1200	2000	2000	2000
Speed	ΔC_{U2}	4000	4000	4000	2800	2200
External Habit	ΔC	4500	1200	500	500	500
Mixture Coefficient	ΔC_{others}	500	500	500	1200	4500
$-u_H/u_C$	Δe	2000	2000	2000	2000	2000
	Δf	20	80	200	400	1000
Hu_{HH}/u_H	Δe	500	500	500	500	500
	Δf	540	600	650	700	800
u_{CH}/u_{HH}	Δe	2000	1600	1000	600	100
	Δf	200	200	200	200	200
u_{CC}/u_{HH}	Δe	500	1500	2200	3000	3500
	Δf	500	500	500	500	500
$u_{C_{others}}/u_H$	ΔC^{U1}_{others}	3000	600	300	150	100
	ΔC^{U2}_{others}	3000	3000	3000	3000	3000
Time Discount	Δe	2000	2000	2000	2000	2000
Rate	Δf	3300	2500	2200	2100	2040

Notes: U1 and U2 means Universe One and Universe Two of the monthly spending graphs. Choosing U1 in the initial question and then U2 in the 1st follow-up question or choosing U2 in the initial question and then U1 in the 1st follow-up question will end the module at the end of the 1st follow-up question (see Figure 7). All amounts are in US dollar.

- No

Under the hypothetical situation of this survey, do things not mentioned in the questions change?

- Yes
- Maybe
- No

Under the hypothetical situation of this survey, how much do people not mentioned in questions always spend per month?

- \$4,000
- \$5,000
- \$6,500
- \$8,000
- No idea