

# A Simple Labor-Leisure Model with Habits: Some Simulations from Previous Results

November 29, 2021

Mark M. Drozd <sup>1</sup>

## Abstract

This paper presents a slight addition mixture of two traditional economic models: the labor-leisure model and a model of habit formation in consumption. We treat labor as a good with which agents form habits over, in addition to already forming habits in consumption behavior. The hope is that this model can be used to explain labor elasticity patterns and life cycle labor supply and consumption differences. This paper is largely inspired by the work of [Bover \(1991\)](#).

**Keywords**     Labor Supply, time allocation, habit formation

PDF: <https://github.com/mmdrozd/CompMethods2021-DrozdMM/ProjectMMD.pdf>  
Slides: <https://github.com/mmdrozd/CompMethods2021-DrozdMM/ProjectMMD-Slides.pdf>  
GitHub: <https://github.com/mmdrozd/CompMethods2021-DrozdMM>

This paper is based off the template for the Theoretical Foundations of Buffer Stock Theory by Chris D. Carroll. The repository for can be found here [put link here]. The paper's results can be automatically reproduced using the Econ-ARK/HARK toolkit, which can be cited per our references (Carroll, Kaufman, Kazi, Palmer, and White (2018)); for reference to the toolkit itself see . All errors are my own.

---

<sup>1</sup>Contact: [mdrozd1@jhu.edu](mailto:mdrozd1@jhu.edu), Department of Economics, Graduate Student Mail Box on 5th floor of Wyman Park Building, Johns Hopkins University, Baltimore, MD 21218

# 1 Introduction

The theory of labor supply tackles one of the most fundamental problems in economics: why people choose to work? Yet, as we try to abstract from the often times complex reasons why agents interact with the labor market, simple features can provide great insights to these problems. As central as such a problem can be, disagreements naturally arise throughout the field; discrepancies between microeconomics and macroeconomics. In an attempt to build some more intuition on such a basic problem, I look to model labor supply in the traditional way, but include habit formation.

The habit formation story is rather intuitive when it comes to consumption. There is a sort of smoothing process in our consumption patterns (a comfort or a certainty in a stochastic world) such that deviations from such norms actually provide disutility. Now, this is a rather extreme case of accustomization to a certain consumption behavior, and as so can be relaxed so as to just suggest the matter of changes in consumption affect utility in a parametric sense. However, this extreme view may hold true. For example, imagine we are analyzing a consumption problem regarding groceries. Deviations from the typical amount that a household purchases for groceries can be disconcerting. For one, there might not be space in the refrigerator to store the food. For another, purchasing more food than a household might use, will make it more likely to spoil and seem like a waste of money.

In the labor supply literature occurs between consumption and leisure, so the same argument justifying habit formation in consumption naturally suggests habit formation in leisure. Agents get used to a certain amount of leisure, and deviations from this amount (particularly decreases) has a large effect. This effect has two channels, one from reducing the current leisure consumption, and the other by this habit. In other words, you are worse off because you don't have the same amount of leisure as before. From the perspective of less leisure in the future, the increasing time demand in labor may make the time spent in leisure less valuable (i.e. when you have leisure, you are too tired from working to take advantage of it compared to your previous leisure amount). On the other hand, too much leisure (relative to a previous period) can also be counterproductive. In this sense, this increase in leisure might lead to idleness and while it may be good to relax a little bit more, the tradeoff to consumption might actually dampen the effect of this extra leisure time. In any case, it is a plausible hypothesis that there may be some degree of habit formation as consumption.

While models of habit formation in consumption tend to dominate (put some cites here), there have been models that introduce habits in labor supply, notably [Bover \(1991\)](#). Using the PSID, [Bover \(1991\)](#) estimates structural parameters of a life cycle labor model imposing a Stone-Geary utility function and non-separability between the current labor supply and previous labor supply. This strategy yields reasonable labor supply elasticity estimates, but these calculations depend on the structural estimates that are implausible. In an effort to see the plausibility of the elasticity estimates, we will simulate agents according to [Bover \(1991\)](#), but restrict some parameters (notably the risk free rate and the psychological discount factor) to the literature standard values.

Some other things about the problem.. perhaps some citations.. you know: make it look pretty.

## 2 The Problem

### 2.1 Setup

An economic agent must decide how much to consume and work each period. The more this agent chooses to work, the more consumption that this agent gets to do, but this comes at the cost of less leisure time (the other “good” that the agent values). Furthermore, the agent has a habit stock in leisure. For the initial setup, let us just assume a finite horizon. The agent looks to maximize the following utility function.

$$\sum_{t=0}^{D-t} \beta^t u(c_t, l_t, h_t^l) \quad (1)$$

$D$  denotes the end of the lifetime. Consumption and leisure are denoted by  $c_t$  and  $l_t$  with  $h_t^l$  being the habit stock of leisure. Each future period is psychologically discounted by the term  $\beta$  (which is less than 1 because otherwise it would not be discounting the future). We assume that the stock of the habits is equal to the previous period’s consumption/leisure.

$$h_{t+1}^l = l_t \quad (2)$$

The agent will maximize her utility subject to the following budget constraint.

$$m_{t+1} = (m_t - c_t)(1 + r) + y_{t+1} \quad (3)$$

$$y_t = W(T - l_t) \quad (4)$$

Equation (3) depicts savings equation. Money/assets are denoted by  $m$ . The income at time  $t$  is denoted by  $y_t$ . Any assets not spent in period  $t$  grows by the risk-free rate (denoted by  $r$ ) to be used for the next period. Equation (4) just describes the earnings in each period. The wage (as of now) is constant and denoted by  $W$  and  $T$  describes the total amount of time in a period. Hence  $T - l_t$  is the amount of time spent in work. We can combine Equations (3) and (4) to have one consolidated budget constraint.

$$m_{t+1} = ((m_{t-1} - c_{t-1})(1 + r) + W(T - l_t) - c_t)(1 + r) + W(T - l_{t+1}) \quad (5)$$

Strictly speaking, we have some additional constraints that apply to this problem. Leisure is censored by zero and  $T$  (it is impossible to have negative leisure or to have more leisure than there is time). Naturally, we have assumed no financing of consumption, which is implicit in the way that Equation (3) is defined.

To solve this model, using a value function is the way to go. Using [Carroll \(2000\)](#) as a guide, we can easily solve the model by putting it into Bellman form.

$$v_t(m_t, h_t^l) = \max_{c_t, l_t} u(c_t, l_t, h_t^l) + \beta v_{t+1}(m_{t+1}, h_{t+1}^l) \quad (6)$$

Combining Equation (6) with Equations (2) and (5), allow us to calculate our first order conditions.

$$u_t^c = \beta(1+r)v_{t+1}^m \quad (7)$$

$$u_t^l = \beta(1+r)Wv_{t+1}^m - \beta v_{t+1}^h \quad (8)$$

The superscripts in Equations (7) and (8) denote the partial derivative with respect to that argument (for example,  $u_t^c = \partial u(c_t, l_t)/\partial c_t$ ). The Envelope Theorem yields the following

$$v_t^m = \beta(1+r)v_{t+1}^m \quad (9)$$

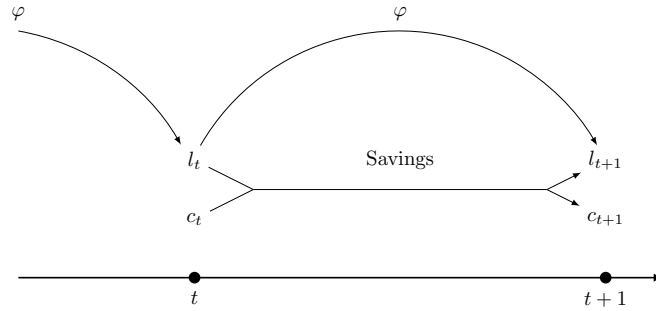
$$v_t^h = u^h \quad (10)$$

Therefore combining our results from our FOCs (Equations (7) and (8)) with the Envelope Theorem results (Equations (9) and (10)), we should get the following Euler conditions:

$$u_t^c = \beta(1+r)u_{t+1}^c \quad (11)$$

$$u_t^l = Wu_{t+1}^c - \beta u_{t+1}^h \quad (12)$$

The Equation (12) is a similar to the optimization condition in classic labor supply theory. In the traditional model, the optimizing behavior equates the ratio of the marginal utilities to the price ratio. By including habits, we gain an extra term that adjusts this condition slightly. As a matter of fact, Equation (12) reduces down to the traditional first order condition when we let  $u^h = 0$  (or in other words, impose that this model does not have a habit aspect).



**Figure 1** Stylized Model

Behold a stylized model of the labor-leisure model with habits.

Figure 1 serves as reference for the model. In essence an agent enters the period and must make a leisure-consumption decision. The leisure decision is influenced by the habit factor,  $\varphi$ . Upon reaching the subsequent period, the decision must be made again, but also takes into account the savings and the habit that came from the previous periods decisions.

In order to continue to solve this problem, we need to impose some functional form

on the utility. Bover (1991) uses a Stone-Geary specification, which is what I will use for consistency purposes<sup>1</sup>.

$$u(c_t, l_t, l_{t-1}) = B_1 \log(c_t - \gamma_c) + B_2 \log(l_t - \phi l_{t-1} - \gamma_l) \quad (13)$$

$B_1$  and  $B_2$  are taste parameters, and homogeneity is assumed, which means that they sum to one. As is usual in the Stone-Geary specification, the  $\gamma_c$  and  $\gamma_l$  parameters can be interpreted as a minimum number of consumption/leisure that the agent needs to attain. Now, we can have continue to work from our first order conditions.

$$\frac{1}{c_t - \gamma_c} = \frac{\beta(1+r)}{c_{t+1} - \gamma_c} \quad (14)$$

$$\frac{B_2}{l_t - \phi l_{t-1} - \gamma_l} = \frac{B_1 W}{c_t - \gamma_c} + \frac{B_2 \beta \phi}{l_{t+1} - \phi l_t - \gamma_l} \quad (15)$$

While Equation (14) is a rather standard Euler equation for consumption, the habit in leisure makes Equation (15) rather complicated. It is further complicated by the presence of a  $c_t$  in Equation (15). This will prevent us from simplying just using the intertemporal budget constraint to give as a nice closed form solution for consumption. In any case, the difficulty of having a second control variable for this problem will call for some simplifications to be made. For the following simulation exercises, I follow Bover (1991). The only notational discrepancy will occur with regards to the psychological discount factor. Moving forward,  $\beta = \frac{1}{1+\rho}$ .

### 3 Simulations

There are several abstractions made in order to simplify the simulation. In principle, we can allow for the wage to change over the life cycle (and perhaps in later renditions, we will allow for this), but for now, we focus on a constant wage. In principle, the Stone-Geary utility function can vary by demographic characteristics. In particular, Bover uses a simple linear regression of demographic observables of which the coefficients on the number of children are reported. Since that is all we have to work with (likely there are other covariates in that regression, but we just do not know their estimated coefficients), we will be restrict our agent to have the mean number of children <sup>2</sup> Potentially in a future simulation, we can also adjust the number of children our simulated agent has<sup>3</sup>.

In order to ensure consistency, I follow the model solution as described by Bover (1991). In Column 2 of Table 1 of Bover (1991), estimates of the structural parameters are pre-

---

<sup>1</sup>Bover (1991) writes utility as a function of labor hours instead of leisure. However, there is not much of a difference in doing so since we assume that time can be divided into either work or leisure. Therefore, we can rewrite everything in terms of labor hours and get the same expressions.

<sup>2</sup>Likely, there my calibration of the  $B_1$  and  $B_2$  values are slightly off since the calculated elasticity for the original paper (as reported in Table 2 is slightly off. But, the numbers are still extremely close, which provides confidence for a correct replication of the the Bover (1991) results.

<sup>3</sup>After all, the mean number of children in the original data is between one and two, which means no one actually has the mean number of children

**Table 1** Calibrated Parameters

Simulation	$\gamma_h$	$\gamma_c$	$\varphi$	$\rho$	$r$
Original	1768.1516	4454.0084	0.2205	0.2429	0.2429
Realistic	1768.1516	4454.0084	0.2205	0.0800	0.0200
Counterfactual	1768.1516	4454.0084	0.3000	0.0800	0.0200
No Habit	1768.1516	4454.0084	0.0000	0.0800	0.0200

sented <sup>4</sup>. Originally, [Bover \(1991\)](#) imposed that the psychological discount factor and the risk free rate were the same, which while that is not terribly radical in and of itself, the point estimates are implausibly large. For instance, the risk-free interest rate falls in the 20% range. Why work when you can get a 20% riskless return.

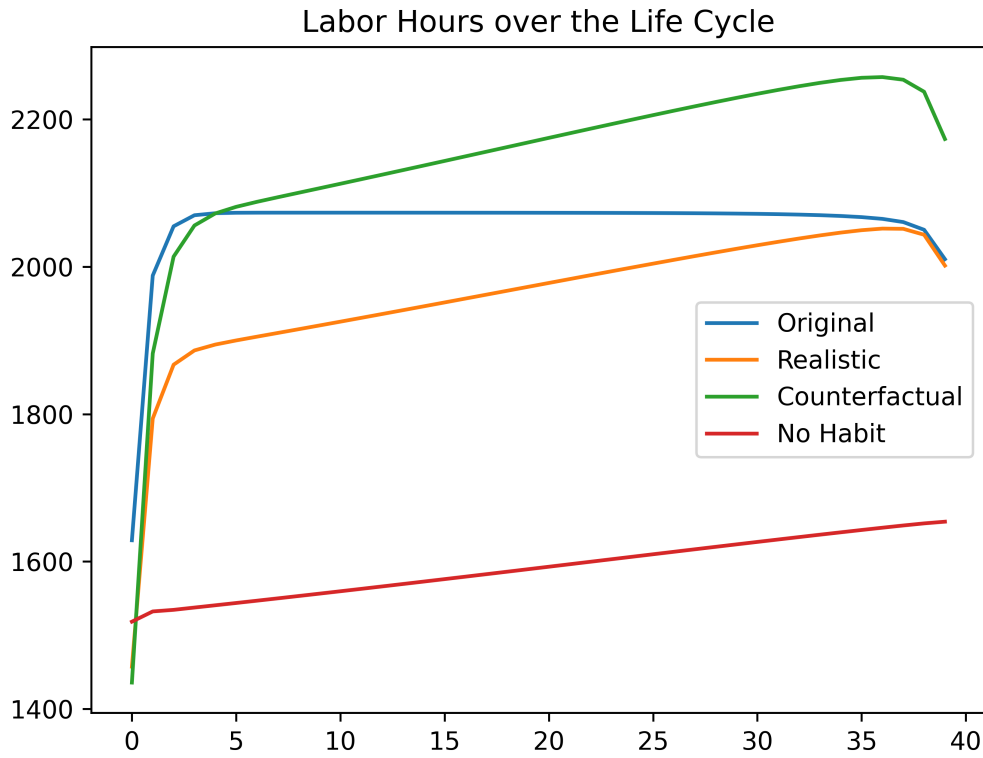
Therefore, the motivation for conducting simulations is clear. For one, there are natural questions that can be asked since life-cycle figures were not presented. What does this model suggest about life-cycle consumption/labor? How sensitive are the results to change in parameters? Does the life-cycle variables change in expected ways when we adjust the parameters?

In conducting my simulation, I maintain a few simplifications. The agent is choosing consumption and labor for a 40-year period. This decision abstracts from reality in two obvious ways. First, there is no mortality (or probability of mortality). Second, the agent does not plan to live for a period of time without work. There is no retirement or no type of Social security system. Furthermore, these decisions are made with certainty. The agent knows that they will be employed at the same wage. This abstraction prevents job separation and the bargaining for higher wages. Some of these features become more standard in a more contemporary life-cycle labor supply model (see [Keane and Wasi \(2016\)](#) for an example of a life-cycle model with these aspects included). Nonetheless, the interesting questions remain and these features provide a foundation for augmenting the habit model for a future project.

The simulations ran are calibrated according to [Table 1](#). The original row refers to estimated values from [Bover \(1991\)](#). The “realistic” row adjusts the  $\rho$  and interest factors to be more standard values. The “counterfactual” row adjusts the same two factors as the “realistic” column, but also adjusts the habit persistence parameter. Finally, the “no habits” row sets the habit persistence variable to zero.

Using these calibrations we are able to simulate the labor hours (and thereby the leisure hours) over the life cycle. [Figure 2](#) demonstrates the life cycle labor hours. Most of the specifications have (generally) the “horseshoe” shape in labor hours, where hours rise at the beginning of life and then fall towards the end. The Original specification most closely follows this shape by maintaining a consistent amount of hours over the life cycle except at the beginning/end. The realistic and counterfactual specifications do not really reach

<sup>4</sup>See the “Original” row of the [Table 1](#) for the point estimates from [Bover \(1991\)](#). It worth noting that many of the point estimates end up statistically insignificant, but yet it is through these point estimates that the author constructs the elasticity estimates.

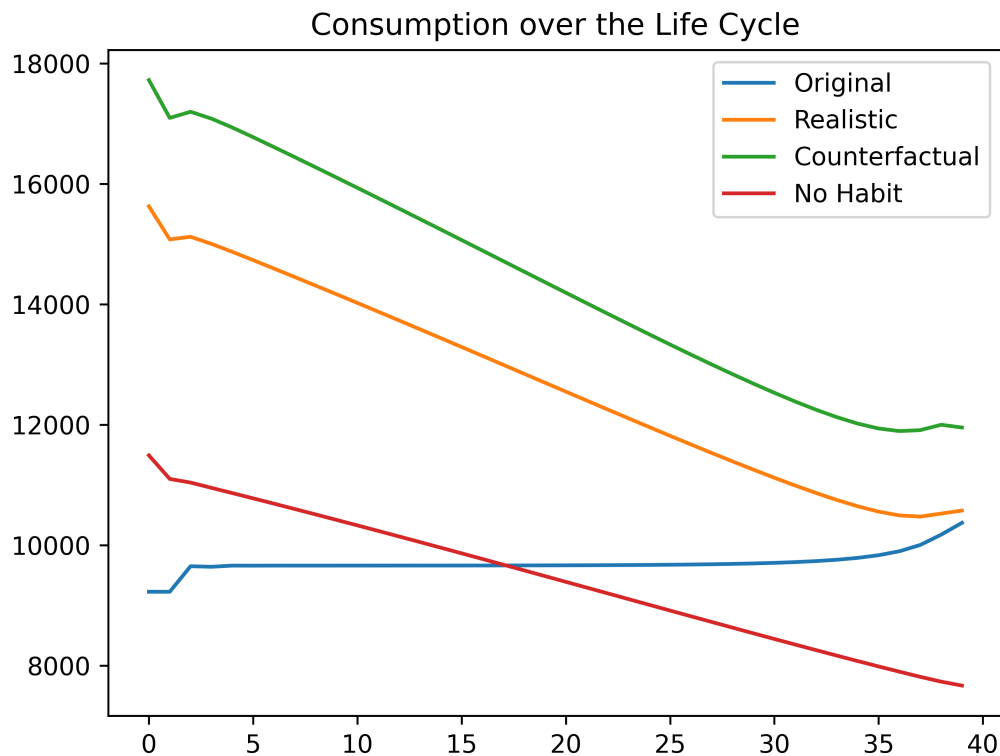


**Figure 2** Annual Labor Hours over the Life Cycle

a “steady” value of labor hours. They increase almost to the very end. A reason for this is that in the original specification, the interest rate is so high, but also being offset by the discount factor. On the other hand, the discount factor is greater in the realistic and counterfactual specifications that cause these agents to prefer consumption and leisure today and pay it off later. Perhaps, the most odd is how low labor hours are for the no-habit case.

Furthermore, Figure 3 presents the life-cycle consumption for all the scenarios. Only the original specification seems to produce what we might think of life-cycle consumption. All the other specifications enjoy immense consumption levels early and then must spend time working to pay off those early levels of consumption. What is interesting is that the increase in  $\phi$  in the counterfactual specification leads to much higher consumption. Keep in mind that this is financed by high labor hours over the life-cycle.

The key conclusion from Bover (1991) is that the including habits produces reasonable labor supply elasticity estimates. Those elasticities are recreated in Table 2.



**Figure 3** Annual Consumption over the Life Cycle

## 4 Conclusions

Here are some food for thought as you finish reading.

## References

- BOVER, OLYMPIA (1991): “Relaxing Intertemporal Separability: A Rational Habits Model of Labor Supply Estimated from Panel Data,” *Journal of Labor Economics*, 9(1), 85–100.
- CARROLL, CHRISTOPHER D. (2000): “Solving Consumption Models with Multiplicative Habits,” *Economics Letters*, 68(1), 67–77, <http://econ.jhu.edu/people/ccarroll/HabitsEconLett.pdf>.
- CARROLL, CHRISTOPHER D., ALEXANDER M. KAUFMAN, JACQUELINE L. KAZIL, NATHAN M. PALMER, AND MATTHEW N. WHITE (2018): “The Econ-ARK and HARK: Open Source Tools for Computational Economics,” in *Proceedings of the 17th Python in Science Conference*, ed. by Fatih Akici, David Lippa, Dillon Niederhut, and M Pacer, pp. 25 – 30. doi: [10.5281/zenodo.1001067](https://doi.org/10.5281/zenodo.1001067).



**Table 2** Simulated Elasticities

Simulation	$\epsilon$	$\eta^\alpha$
Original	0.0806	-0.1282
Realistic	0.1232	-0.1287
Counterfactual	0.1246	-0.1179
No Habit	0.1112	-0.1577

KEANE, MICHAEL P, AND NADA WASI (2016): “Labour Supply: The Roles of Human Capital and the Extensive Margin,” *The Economic Journal*, 126(592), 578–617.