Engines of Leisure

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Abstract

U.S. time use patterns have changed over the last century in ways that appear inconsistent. Leisure has increased with income but has increased most for the poorest. I develop a unified model that treats leisure as an economic activity. Leisure services are produced using capital, like televisions, and non-market time. Doing so improves the labor supply predictions of macro models. The model's U.S. labor wedge more closely matches observable labor market distortions. It is also is consistent with the observed reversal in 20th Century leisure inequality, where high income workers went from working less to more than low income workers. Leisure capital reinforces inequality; poorer households have more leisure hours but less capital.

JEL classification: E2, J2

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1 Introduction

A large literature has sought to explain trends in work hours both within and across countries. It has been difficult to obtain a consistent explanation of these trends. For example, market hours have fallen in the last 100 years in the United States (Ramey & Francis 2009) and a number of other countries (Huberman & Minns 2007, Bick, Bruggemann & Fuchs-Schundeln 2016). Income effects will generate this fact, as documented in Ngai & Pissarides (2008) among others. However, this mechanism fails to account for increasing leisure inequality, with high income household working relatively more since 1980 (Gimenez-Nadal & Sevilla 2012, Attanasio, Hurst & Pistaferri 2015).

I show that many of these inconsistencies can be resolved by treating leisure as an economic activity with preferences where consumption and leisure are non-separable. In contrast to the typical treatment, where the value of leisure only depends on time, leisure production uses both leisure capital and non-market time. Durable goods, such as televisions, increase the amount of enjoyment households get from their leisure time. This treatment is intuitive. Durable recreational goods, such as radios, television and video players, were adopted quickly after introduction, suggesting that people value the entertainment they provide. It also allows for preferences for leisure time to vary over time, as Hall (1997) argues they do, without appealing to mysterious (and unmeasurable) preference shocks.

These changes improve the labor supply predictions of macro models. The model predicts that higher income pushes leisure time up, as in Ngai & Pissarides (2008), Vandenbroucke (2009), and Boppart & Krusell (2016), leading to a long run decline in market work. However, there are forces that can blunt this decline. Since leisure can be produced by either capital or "labor" (leisure time), changing relative input prices will cause a shift to the cheaper input. Lower leisure capital prices will shift leisure production toward this capital, freeing time for market work. Therefore, the model can accommodate both the longer term increase in leisure time and the slow increase after World War Two despite continuing wage growth.

I investigate these forces quantitatively by parameterizing the model for the post World War Two U.S. economy. The U.S. labor wedge–the implied labor tax required to generate observed hours– fell beginning in the 1980s (Karabarbounis 2014, Cociuba & Ueberfeldt 2015). Measurable distortions, such as income tax rates, do not fall enough to explain the significant increase in labor supply (Mulligan 2002). Including leisure capital eliminates a significant portion of the post-1980 decline in the U.S. labor wedge. The labor wedge with leisure capital matches up with observable movements in taxes much better than the model without it. There has been a decline in the relative price of leisure capital, leading households to substitute from time to capital in the production of leisure.

The model can also help explain the reversal in the nature of leisure inequality. Early in the 20th Century, high income households worked less than low income households (Costa 2000). This pattern has reversed, with high income household working relatively more since 1980 (Gimenez-Nadal & Sevilla 2012, Attanasio et al. 2015). The model predicts that high wage households work relatively less if inequality is due to differences in capital holdings and the reverse for wage inequality. The reversal in leisure inequality coincides with a change in inequality from capital to wage differences.

Leisure capital tends to reinforce the recent rise in inequality. While poorer households have more leisure hours, they have less access to leisure capital. Therefore, those hours do not produce as many leisure services. In the baseline case, doubling wages will mean that household will produce 6 percent more leisure per hour.

Modeling labor supply correctly is a foundational issue in economics. It has implications for a large number of issues beyond the obvious ones such as time allocation or business cycle modeling. For example, the details of how people value leisure has a significant impact of evaluating countercyclical fiscal policy. Such policy has more impact if consumption and market hours are complements, as in Bilbiie (2011) and Nakamura & Steinsson (2014).

Previous work has examined the impact of recreational goods on labor supply. Vandenbroucke (2009) considers a model with leisure production. The major difference is in focus -

he examines changes in hours prior to 1950 - while this paper focuses on the period after 1950. Ngai & Pissarides (2008) include a leisure sector that uses capital. Again, the major difference is in focus; they examine structural change. Empirical work includes Gonzalez-Chapela (2007) and Gonzalez-Chapela (2011), which estimates the elasticity of labor supply with respect to recreational goods prices for men and women respectively. Earlier work in this vein include Owen (1971) and Abbott & Ashenfelter (1976).

Other papers have considered the value of leisure as a combination of time and goods. This literature begins with Becker (1965). Goolsbee & Klenow (2006) use such a framework to examine the value of using the internet. Kaplow (2010) examines taxation of market goods that are complements to leisure. Soloveichik (2014) examines the value of “free” entertainment. Gronau & Hamermesh (2006) examine the time and goods intensity of household activities.

A related issue is that GDP (intentionally) only covers a portion of items that contribute to welfare. Therefore, welfare comparisons based only on GDP may give misleading answers (Stiglitz, Sen & Fitoussi 2009, Diewert & Schreyer 2014, Jones & Klenow 2016). It may also distort interpersonal comparisons. Accounting for leisure gives a fuller picture for such comparisons. Depending on its valuation, the increase in leisure inequality may increase or decrease welfare inequality.

This paper examines a mechanism to explain the long run movement in labor wedges. The literature has considered other mechanisms, including changing gender wage gaps (Cociuba & Ueberfeldt 2015) and improving job quality (Epstein & Kimball 2014). There is also a closely related literature that examines its business cycle frequency movements, including Shimer (2009), Bigio & La’O (2013), Bils, Klenow & Malin (2014) and Gourio & Rudanko (2014). Other papers, such as Benhabib, Rogerson & Wright (1991) and Greenwood & Hercowitz (1991), have expanded models to include non-market home production improved model fit at these frequencies. While this paper can help in resolving this question, it is not the primary focus.

2 Facts

This section examines the facts on leisure that this paper addresses. Specifically, I examine the long run trend in leisure time and the distribution of leisure across income groups, with an emphasis on U.S. data.

U.S. leisure time has increased over the last 100 years. Ramey & Francis (2009) find a 10 percent increase in leisure hours since 1900. This is a more conservative estimate than Aguiar & Hurst (2007), who find an increase since 1965, a period that Ramey & Francis (2009) find little increase. Much of the difference comes in the details of coding activities as work or leisure.

An issue with these data is that the source data for the early years are sporadic and lower quality than the more recent data. Therefore, trends may be obscured by measurement error. Market hours, the category of time use with the highest quality early data, shows a distinct downward trend. The average work week fell from 60 to 40 hours from 1900 to 1950 while annual weeks and lifetime years of work fell (Vandenbroucke 2009).

A common explanation of this trend is increasing incomes (Ngai & Pissarides 2008). The evidence is mixed. Bridgman, Duernecker & Herrendorf (2015) examine time use surveys for a number of countries and do not find an increasing leisure trend in income. In contrast, Bick, Fuchs-Schundeln & Lagakos (2015) find that market work is declining in income. The Bridgman et al. (2015) sample is smaller and cover higher income countries but includes information about household production.

Another explanation is that these trends are due to labor taxes (Prescott 2004). The evidence indicates that these trends are not simply the result of policy. U.S. labor wedge movements do not match observable distortions. As discussed above, there was a decline in the U.S. labor wedge that was not matched by observable tax changes. Bridgman et al. (2015) find market time is not correlated with taxes in their panel of middle and high income countries and conclude that changes in technology are likely to be important. Bick et al. (2016) adjust OECD data for underreporting of holidays and argue that taxes cannot explain the cross-sectional variation in market hours. Even analysis that uses very detailed tax and transfer policy with heterogeneous households, such as vom Lehn, Gorry & Fisher (2016), find a relatively small role for policy.

There have been shifts in the distribution of leisure hours across income groups. Costa (2000) finds that low wage workers had long work weeks in 1890s while the opposite was true in 1991. Looking at data beginning in 1985, Attanasio et al. (2015) find that less educated workers have been spending more time in leisure compared to more educated workers in the United States. These patterns hold in the United States back to 1965 (Fang, Hannusch & Silos 2016) and for other high income countries (Gimenez-Nadal & Sevilla 2012).

Despite having fewer leisure hours, high income households spend a higher share of their income on leisure goods (Fang et al. 2016). This evidence is consistent with high income households trading off leisure time for recreational goods, the mechanism emphasized in this paper.

3 Model

This section presents the model. It features an infinitely lived representative household with three production sectors: market, household and leisure. All three sectors use household's time and labor to produce output. I characterize the equilibrium and demonstrate how time allocation is determined in a static version of the model.

3.1 Environment

The representative household's preferences over market and home consumption goods (C_t^m and C_t^h respectively) and leisure l_t are represented by the utility function:

$$\sum_t \beta^t \frac{[C(C_t^m, C_t^h)\exp(\phi \frac{l_t^{1-\epsilon}}{1-\epsilon})]^{1-\sigma}}{1-\sigma} \tag{3.1}$$

This utility function is a member of the class proposed by King, Plosser & Rebelo (1988). (See Sims (2015) for a description of its attributes.) The functional form implies that consumption c and leisure l are substitutes. Boppart & Krusell (2016) argue that this class is required to explain long term changes in hours.

The household has a unit of time that it can allocate to market, home or leisure production, designated by the superscripts m, h and l respectively. The share of time devoted to each activity given by H_t^j for $j \in \{m, h, l\}$:

$$H_t^h + H_t^m + H_t^l \leq 1 \tag{3.2}$$

Market time earns a wage w_t^m.

Leisure is produced using leisure production time H_t^l and leisure capital K_t^l:

$$l_t = (K_t^l)^{\alpha^l} (H_t^l)^{1-\alpha^l} \tag{3.3}$$

The home consumption good is produced using home hours H_t^h and home capital K_t^h:

$$C_t^h = (K_t^h)^{\alpha^h} (H_t^h)^{1-\alpha^h} \tag{3.4}$$

The laws of motion for the capital stocks K_t^j for $j \in \{l, h\}$ is given by:

$$K_{t+1}^j = K_t^j (1 - \delta^j) + X_t^j \tag{3.5}$$

where X_t^j is investment and δ^j is depreciation. The market rate of return is given by R_t^m.

Market consumption and both types of investment are produced by a market technology

$$C_t^m + \sum_j X_t^j / B_t^j = (K_t^m)^{\alpha^m} (H_t^m)^{1-\alpha^m} \tag{3.6}$$

The price of investment good X_t^j is q_t^j. The price of market consumption is numeraire.

There is a government that can levy taxes and make lump sum transfers T_t. Labor taxes τ^l are levied on the market wage w_t^m. Consumption taxes τ^c are paid on both market consumption C_t^m and both leisure and household investment X_t^l, X_t^h. This treatment accords with most tax systems which treat consumer durables as regular consumption, not capital. Investment taxes τ^x and τ^k are levied on market investment X_t^m and capital returns R_t^m respectively.

3.2 Equilibrium

The representative household's problem is to maximize utility subject to the period budget constraint

$$(1+\tau^c)(C_t^m + q_t^l X_t^l + q_t^h X_t^h) + (1+\tau^x) q_t^m X_t^m = (1-\tau^l) w_t^m H_t^m + (1-\tau^k) R_t^m K_t^j + T_t \quad (3.7)$$

and the leisure and home consumption production functions (Equations 3.3 and 3.4) and the laws of motion (Equation 3.5.)

The firm's problem is to maximize $C_t^m + \sum_j q_t^j X_t^j - R_t^m K_t^m - w_t^m H_t^m$ subject to the production function (Equation 3.6).

The definition of equilibrium is standard.

Definition 3.1. *An equilibrium is sequences of prices* $\{w_t^m, R_t^m, q_t^j\}$ *and quantities* $\{C_t^m, C_t^h, l_t, K_t^j, X_t^j, H_t^j\}$ *such that, given prices and policy,*

1. *Households choose* $\{C_t^m, C_t^h, l_t, K_t^j, X_t^j, H_t^j\}$ *to solve their problem;*
2. *Market firms choose* $\{C_t^m, K_t^m, X_t^j, H_t^m\}$ *to solve their problem;*
3. *Government balances its budget;*
4. *Allocations are feasible.*

3.3 Model Mechanics

Since the full model is rather complex (a dynamic model with three sectors), I will begin with a simplified version to examine how the model works. I will then add back model features. I use the full model for the quantitative exercises. In this section, I set depreciation to 100 percent and set taxes to zero ($\delta^j = 1, \tau^j = 0$). This reduces the clutter and allows us to concentrate on the primary forces in the model. I use the Basu-Kimball style utility function, a log linear form of the utility function: $\eta \ln(C^m) + (1-\eta)\ln(C^h) + \phi \frac{l_t^{1-\epsilon}}{1-\epsilon}$.

Equation 3.8 reports leisure hours in terms of market prices and quantities.

$$H_t^l = \left[\frac{C_t^m \phi}{w_t^m}\right]^{\frac{1}{\epsilon}} \left[\frac{q_{t-1}^l (1-\alpha^l) R_t^m}{w_t^m \alpha^l q_{t-1}^m}\right]^{\frac{\alpha^l(\epsilon-1)}{\epsilon}} \tag{3.8}$$

I use this equation to examine the comparative statics of the model.

The first force is that a greater market consumption/wage $\frac{C_t^m \phi}{w_t^m}$ ratio increases leisure time. This is related to the income effects emphasized by Ngai & Pissarides (2008), Vandenbroucke (2009) and Boppart & Krusell (2016). This force is present whether or not there is leisure capital.

If there is leisure capital ($\alpha^l > 0$), increasing leisure investment price/wage ratio $\frac{q_{t-1}^l}{w_t^m}$ also increases leisure time. This ratio is the relative cost of the two inputs in leisure production. A lower wage makes “labor” relatively cheap, so the household uses relatively less capital.

Leisure capital gives an additional channel to explain labor/leisure decisions. Falling leisure capital costs counteract income effects. Lower leisure capital prices shifts leisure production toward this capital, freeing time for market work. This finding is consistent with Gonzalez-Chapela (2011), who find that higher recreational goods prices reduce female labor force participation.

With this additional force, the model can accommodate both an increase in leisure time in the long term and the slower increase after World War Two despite continuing wage growth. The increase in leisure capital will blunt the income effects. It is notable that the stock U.S. recreational capital increases from 13 percent to 21 percent of household durable goods stocks from 1950 to 1975 after being flat from 1929 to 1950[1]. Vandenbroucke (2009) identifies 1950 as the time of a shift in the elasticity between consumption and leisure.

[1]BEA Fixed Asset Table 8.1, lines 1 and 11, August 2015 vintage.

Some have suggested that changes in leisure technology can explain falling LFP since leisure innovations make not working more attractive and so people work less (Aguiar, Bils, Charles & Hurst 2016). U.S. prime-age male labor force participation has declined since the 1960s. This withdrawal from market work during the peak earning years is not explained by movement to other productive activities (home production or education) or due to inability to work (disability). (See U.S. Council of Economic Advisors (2016) for a recent summary of this evidence.) The main difference in time use between non-employed men and those in the labor market is the amount of time on leisure activities: Non-participants spend the time participants use working on leisure (Stewart 2008).

The model predicts that cheaper leisure capital increases LFP, the opposite of this intuition. How do we square falling leisure capital prices and falling LFP with the model? The evidence suggests that wages are a prime cause of these changes. The decline is LFP is concentrated in the lowest educational attainment groups, whose wages have lagged. We also do not see the same effects for women, who also value leisure. A falling gender wage gap meant that women's wage tended to grow during this period compared to men. They are also less likely to have criminal records, so face less of the stigma effects on wages.

The model does not feature a balanced growth path if there is leisure capital ($\alpha^l > 0$). This implies that in the long run market hours either drop to zero or increase to all waking hours. For the baseline parameters below, leisure capital can increase by large amounts without having enormous impact on hours. If per capita leisure capital grows by a factor of 10, leisure hours only decline by 9 percent. Increasing income will also work against this effect, keeping hours from hitting the boundary.

In the rest of the paper, I will show how adding this mechanism can improve the time allocation predictions of macro models. I begin with a qualitative examination of leisure inequality. I then perform a quantitative examination of postwar time allocation.

4 Leisure Inequality

As documented above, there has been an increase in leisure inequality since 1980. This fact presents a challenge for existing time allocation models. Income effects can explain increasing leisure hours but cannot explain the current pattern of leisure inequality since higher income households should work less, not more.

The model is able to generate the reversal of inequality since the nature of income inequality matters for leisure inequality. If inequality is due mostly to asset inequality, then the wealthy take more leisure than the poor. The opposite is true if inequality is due to wage inequality.

I proceed by solving the hours equation (Equation 3.8) in terms of prices. For an interior solution,

$$(H_t^l)^\epsilon[\frac{w_t^m}{q_{t-1}^l}\Phi_1]^{\alpha^l(\epsilon-1)}[\Phi_2-\Phi_3(\frac{q_t^l}{w_{t+1}^m})^{\alpha^l(\epsilon-1)}]+H_t^l\Phi_4+\Phi_5 = [1-(H_t^l)-(H_t^l)^\epsilon(\frac{w_t^m}{q_{t-1}^l}\Phi_6)^{\alpha^l(\epsilon-1)}]\Phi_7+\frac{T_t}{w_t^m} \tag{4.1}$$

The terms Φ_i are collections of parameters and prices that are reported in the Appendix.

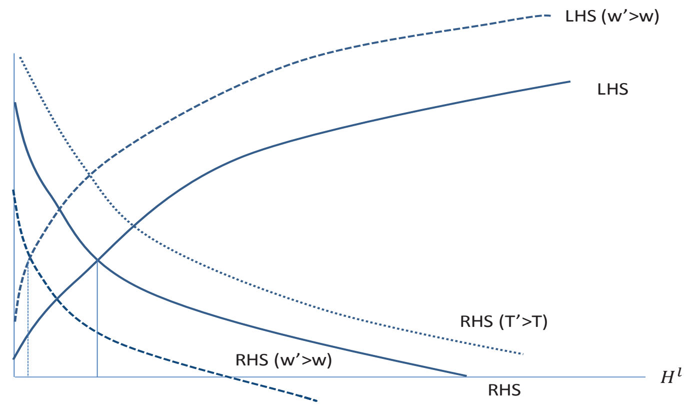
I use this equation to perform comparative statics. Since it includes prices from more than one period, I have to take a stand on the time path of prices. For changes to wages, I assume that prices in all periods is scaled by a constant factor. For example, for wages: $w_t^{m,\prime} = \gamma w_t^m$.

This equation generates two important comparative statics. First, a higher wage reduces leisure hours. Figure 1 shows graphically the impact of this change. In addition to increasing the value of working, a higher wage makes labor inputs to leisure production relatively more expensive. Both forces will tend to increase market hours.

Second, higher non-wage income T_t increases leisure hours. It increases income, which reduces market time, without increasing the relative price of "labor" in leisure production.

To examine impact of income inequality on leisure inequality, I compare the model's predictions for two types of households, Rich (R) and Poor (P). High income households may

Figure 1: Hours



receive non-wage income T_t^R and receive wage $w^{m,R}$. Poor households only have labor income, from the wage $w^{m,P}$. I use this stark assumption on asset holdings, which has been used in the recent inequality literature (e.g Karabarbounis & Neiman (2014)), for expositional clarity.

I compare two forms of inequality. In the first, wages are the same ($w_t^{m,R} = w_t^{m,P}$) but the Rich receive non-wage income $T_t^R > 0$. In the second, the rich have higher wages ($w_t^{m,R} > w_t^{m,P}$) but neither Rich nor Poor have non-wage income $T_t^R = 0$.

In the case of asset inequality, the Rich have more leisure hours than the Poor. Asset inequality affects labor supply through a pure wealth effect. Higher non-wage income shifts labor supply in, so richer people work less.

Now suppose that the Rich earn higher wages. In addition to increasing the returns to working, higher wages allows the household to buy more leisure capital which reduces the opportunity cost of working. Therefore, richer people are more willing to work.

If the Rich have both higher wages and assets, the higher wage counters the market work suppressing force of the assets. The final term of the RHS goes to zero as wage $w_t^{m,R}$

increases.

Wage inequality tends to exacerbate income inequality since higher wage people work more hours, earning yet more income. In contrast, inequality in capital income leads the rich to reduce hours and thus compresses labor earnings.

The model is consistent with the reversal of leisure inequality if capital inequality was the driving factor for inequality in the past while wage inequality matters more now. In fact, Kopczuk (2015) finds that labor income inequality is the driving factor for inequality recently while capital inequality was important in the 1920s. Gimenez-Nadal & Sevilla (2012) find some evidence of a similar time series movement in other high income countries.

Leisure capital tends to reinforce inequality in the recent situation. While poorer households have more hours, they have less leisure capital. Therefore, those hours do not produce as many leisure services. This finding is consistent with inequality in self-reported wellbeing. Stevenson & Wolfers (2008) find that more educated workers report higher wellbeing. It is consistent also with Sevilla, Gimenez-Nadal & Gershuny (2012), who argue that the quality of poorer household's leisure is worse than higher income households. Gonzalez-Chapela (2014) finds that high income workers increase the quality rather than hours of leisure.

The productivity of leisure time is

$$\frac{l_t}{H_t^l} = \left[\frac{\alpha^l w_t^m q_{t-1}^m}{(1-\alpha^l) q_{t-1}^l R_t^m} \right]^{\alpha^l} H_t^l \tag{4.2}$$

An hour of leisure time for a high wage household generates more leisure than for a low wage household since they hold more leisure capital. The ratio of the "productivity" of leisure time is given by

$$\frac{l_t^R}{H_t^{l,P}} / \frac{l_t^P}{H_t^{l,P}} = \left[\frac{w_t^{m,R}}{w_t^{m,P}} \right]^{\alpha^l} \tag{4.3}$$

How much more productive high wage workers' leisure time is depends on how important capital is in its production. In the standard model without leisure capital ($\alpha^l = 0$), there is no difference between high and low wage workers. Larger capital share α^l increases the gap in leisure productivity. In the baseline parameterization below, with $\alpha^l = 0.08$, a doubling of wages will increase leisure productivity 6 percent.

Non-market activity does not fully counteract the welfare impact of income inequality. Household production compresses inequality, but does not undo inequality since rich and poor household consume similar amounts of this consumption (Frazis & Stewart 2011). Non-market forces may even accentuate the recent increase in income inequality. Household production has become is less important as it is marketized while high income households can counteract their fewer leisure hours with more recreational purchases.

5 Impact of Taxes and Transfers

An important literature related to labor supply attempts to explain the differences in labor hours across countries using policy. Prescott (2004) argues that differences in taxes explain differences across the United States and Europe. A large literature agrees that government policy is an important reason for the differences[2].

However, this literature has difficulty explaining the time series of labor allocation. The taxes required to explain movements in U.S. labor supply do not match observable taxes. I show that the inclusion of leisure capital improves the model's fit. I proceed by extending the qualitative analysis above to include taxes and transfers. I then perform a quantitative exercise where I parameterize the model and show that the implied labor wedge matches empirical taxes much better.

[2]Examples include Rogerson (2006), Ljungqvist & Sargent (2007), Ohanian, Raffo & Rogerson (2008), Rogerson (2008), Olovsson (2009), Ngai & Pissarides (2011) and Duernecker & Herrendorf (2014).

Allowing for non-zero labor and consumption taxes, the hours equation becomes

$$(H_t^l)^\epsilon \left[\frac{(1-\tau^l)w_t^m}{(1+\tau^c)q_{t-1}^l}\Phi_1\right]^{\alpha^l(\epsilon-1)} \left[\Phi_2(1-\tau^l) - \Phi_3\frac{q_t^l(1+\tau^c)}{w_{t+1}^m(1-\tau^l)}\right] + H_t^l\Phi_4' \left[\frac{(1-\tau^l)\alpha^l}{1-\alpha^l} - \frac{\alpha^m}{1-\alpha^m}\right] + \Phi_5$$
$$= \left[1-(H_t^l)-(H_t^l)^\epsilon\left(\frac{(1-\tau^l)w_t^m}{(1+\tau^c)q_{t-1}^l}\Phi_6\right)^{\alpha^l(\epsilon-1)}\right]\left[\frac{\alpha^m}{1-\alpha^k}+1-\tau^l\right] + \frac{T_t}{w_t^m} \quad (5.1)$$

This equation generates a number of comparative statics. Several are unsurprising given the previous analysis. Holding prices, other taxes, and transfers constant, higher labor taxes increase leisure hours since it reduces wages. This force is present even if leisure does not use capital ($\alpha^l = 0$), though it is lessened. Households do not have the labor/capital tradeoff in leisure production but the returns to work are still lower.

Analogous to the asset inequality result above, transfers increase leisure time. This result points to a tension between improving market indicators and welfare. To increase market hours, it is better to waste the government's revenue than transfer it to the household. Doing so suppresses consumption, encouraging market work. However, such a policy would not be welfare enhancing. It generates more market hours by impoverishing the household.

Consumption taxes reduce leisure capital, discouraging market work. This effect works entirely through the leisure sector. If leisure does not use capital, it is eliminated. Consumption taxes are charged on leisure investment, so these taxes have the same effect as increasing the investment price. This is the opposite intuition of that in Kaplow (2010), who argues for taxing leisure goods to increase market hours. The difference is that leisure goods are substitutes for time in my model, not complements.

6 Labor Wedge

I now turn to the quantitative analysis of how well the model does in accounting for leisure time. To evaluate the model, I will examine the labor wedge. Parkin (1988), Chari, Kehoe & McGrattan (2007) and others have used this measure as way of evaluating models. It is the implied labor tax required to generate observed hours. I will calculate the wedge with and without leisure capital. This approach allows us to abstract from other forces to focus on what is new in this model. I show that including leisure capital makes the predicted wedges much closer to empirical tax wedges.

A robust finding in the literature is there has been a decline in the U.S. labor wedge beginning in the 1980s (Karabarbounis 2014, Cociuba & Ueberfeldt 2015). Measurable distortions, such as income tax rates, do not fall enough to explain the significant increase in labor supply (Mulligan 2002).

6.1 Solution

I use the more general CES consumption aggregator in the utility function: $C(C^m, C^h) = [\psi C_m^\eta + (1-\psi)C_h^\eta]^{\frac{1}{\eta}}$. I examine the household's choices of market hours taking prices as parameters.

The labor wedge Δ is given by

$$1 - \Delta = \left[\frac{C_t^m}{(H_t^l)^\epsilon} \phi (1 + \frac{(1-\psi)}{\psi} [\frac{C_t^H}{C_t^m}]^\eta) \right]^{\frac{1}{1+\alpha^l(\epsilon-1)}} \left(\frac{1-\alpha^l}{w_t^m} \right) Q_t \tag{6.1}$$

where

$$Q_t = \left[\frac{q_t^l}{\alpha_t^l} \left(\frac{(1+\tau_t^x) q_t^m}{(1+\tau_{t-1}^x) q_{t-1}^m} (1-\delta^m) - \frac{(1+\tau_t^c) q_t^l}{(1-\tau_{t-1}^c) q_{t-1}^l} (1-\delta^l) + \frac{(1-\tau_t^k) R_t^m}{(1+\tau_t^x) q_{t-1}^m} \right) \right]^{\frac{\alpha^l(\epsilon-1)}{1+\alpha^l(\epsilon-1)}} \tag{6.2}$$

I compare the full model's predictions with a couple of counterfactuals. "No Non-Market" eliminates leisure capital ($\alpha^l = 0$) and removes household production. Leisure time is all non-market time. "No Leisure K" sets $\alpha^l = 0$ but includes household production. Note that $Q_t = 1$ when $\alpha^l = 0$

6.2 Data

Most data are standard macro variables. NIPA data are from the Bureau of Economic Analysis. (See the data appendix for full descriptions.) For consumption, I use non-durable and services

PCE per capita to avoid double counting leisure and household capital. I use market hours and working age population from Cociuba, Prescott & Ueberfeldt (2012), updated to 2014 using the method put out in the data files for McGrattan & Prescott (2012). I set per capita leisure hours to 5200 less work hours. I use 5200 since working age people typically have 100 of non-sleep or personal care hours per week in a broad set countries, including the United States (Bridgman et al. 2015). p^l is the price of recreational durables.

To measure household production, I use the output and hours estimates of Bridgman, Dugan, Lal, Osborne & Villones (2012) and Bridgman (2016*b*). To avoid double counting, I use the restrictive definition of home production in Bridgman (2016*b*) that excludes recreational capital and the portion of autos used for market work commuting. I update these data to 2014 using Bridgman (2016*a*). I use the market services PCE deflator to obtain real home output.

I compare the computed wedges with empirical wedges from tax rates. This wedge is $(1 - 1.6 * \tau_i - \tau_{ss})/(1 + \tau_c)$, where $\tau_i, \tau_{ss}, \tau_c$ are income, social security and consumption taxes respectively from McDaniel (2011). Following Prescott (2004), I scale up income taxes by 1.6 to account for the difference in average and marginal tax rates. Based on this data, I select ϕ to set the labor wedge to the 1960 level in all simulations.

6.3 Parameters

To examine the quantitative impact of adding leisure capital, I calculate the labor wedge for the United States with and without such capital. I parameterize the model and feed in U.S. macro data.

Following the literature, I set $w^m = (1 - \alpha^m)Y_t^m/H_t^m$ and $R^m = \alpha^m Y_t^m/K_t^m$ the marginal products of labor and capital for a Cobb-Douglas production function. I set $\alpha^m = 0.33$.

There is a great deal of controversy about the correct value for the Frisch elasticity, the response of hours to changes in wages holding consumption fixed. Equilibrium leisure hours can be written as

$$H_t^l = (w_t^m)^{\frac{-1}{1+(1-\alpha^l)(\epsilon-1)}} \left[\frac{\phi(1-\alpha^l)(C_t^m)^{1-\eta}[\psi(C_t^m)^\eta + (1-\psi)(C_t^h)^\eta]}{\psi(K_t^l)^{\alpha^l(\epsilon-1)}}\right]^{\frac{1}{1+(1-\alpha^l)(\epsilon-1)}} \tag{6.3}$$

The elasticity is $-1/[\alpha^l(\epsilon-1)-\epsilon]$. I use a target value of 0.75 as recommended by Chetty, Guren, Manoli & Weber (2011). It is governed by both the preference parameter ϵ and the capital share in leisure production.

There is little guidance in the literature on the value of α^l. Bridgman (2016*c*) finds that this capital share is smaller than market capital share, between 4 and 8 percent. This estimate is a lower bound for capital share for working age people. Bridgman (2016*c*) uses all adult leisure time, so includes a great deal of retirees' and other non-market participants leisure. Leisure should be valued at a person's wage. Since those wages are not observable for non-workers, non-market participants leisure is valued at (likely higher) workers' wages. This will overestimate labor share since the sector's labor income is overvalued. I set α^l to 0.08 since it is the upper end of the Bridgman (2016*c*) estimates. It is also the durables share that Duernecker & Herrendorf (2014) use for household production. The Frisch elasticity target implies $\epsilon = 1.36$.

I use the consumption parameters from Jones, Manuelli & McGrattan (2014) and set elasticity parameter $\eta = 0.429$ and the market share in consumption $\psi = 0.682$. There is not a strong consensus on what this parameters should be. This value is within the range found by empirical estimates on micro data such as Rogerson, Rupert & Wright (1995), Gelber & Mitchell (2012) and Moro, Moslehi & Tanaka (2015) and theoretical work such as Benhabib et al. (1991) and Guler & Taskin (2013).

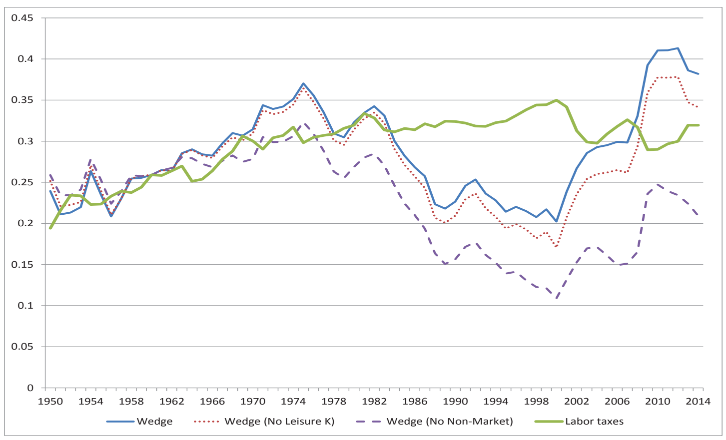
Table 1: Parameters

α^m	α^l	ϵ	η	ψ
0.33	0.08	1.36	0.429	0.682

6.4 Simulations

Figure 2 reports the simulations and empirical labor wedges. The wedge with neither leisure capital nor household production ("No Non-Market") shows the early 1980s fall in labor wedge that is common in the literature. This pattern does not match the empirical wedge from taxes, which shows no such decline.

Figure 2: Labor Wedges, 1950-2014



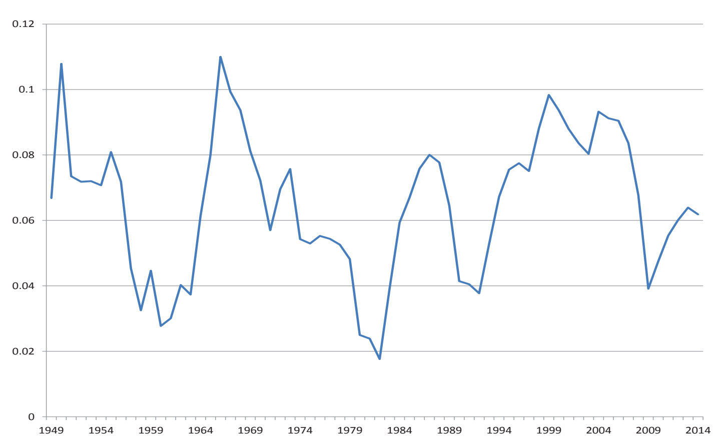
The full model's wedge ("Wedge") performs better on two margins. The model wedge has a sustained increase from 1960 to the early 1980s, matching a similar increase in labor taxes. Both measures increase 5 percentage point from 1960 to 1984. Aside from overshooting in the early 1970s, perhaps due to business cycles, the model wedge and labor taxes time series are quite close. In contrast, the "No Non-Market" wedge shows no such sustained increase. In fact, it falls slightly between 1960 and 1984. It only shows an increase due to the business cycle frequency fluctuations.

The full model also better matches the post-1984 period better than the model without the non-market sectors. Labor taxes are flat during this period. The model shows no sustained decline between 1984 and 2007, while the "No Non-Market" wedge falls 10 percentage points over the same period. The full model does have a decline in the 1980s and 1990s, but it is smaller than the "No Non-Market" wedge's decline. Between 1984 and 2000, the model wedges fell 33 percent while the "No Non-Market" wedge fell 56 percent.

Which non-market sector improves the model's predictions changes over time. In the 1960s, household production is more important. Home production slows consumption growth since some of the growth rate of market consumption is due to shifting production from home to market services ("marketization."). Leisure capital has a small impact in the 1960s: The full model and "No Leisure K" wedges are very similar.

Leisure capital becomes more important over the sample. Marketization reduces household production's contribution while the relative price of leisure capital falls, encouraging its accumulation. Leisure capital becomes quantitatively important in the 1980s. The "No Leisure K" wedge falls 41 percent between 1984 and 2000, much more than the full model (33 percent). Leisure capital is also important for returning the full model wedge to its early 1980s level.

Figure 3: Growth Rate of Real Recreational Goods Stocks per Capita, 1949-2014



Many of the model's deviations from empirical wedges are associated with business cycles. The wedges are cyclical, increasing during recessions. This effect is very significant increase during the Great Recession, though it is beginning to decline[3]. Part of the explanation may be that durable goods purchases are cyclical in the data, so leisure capital stocks will decline in recessions. Shocks that reduce these stocks will persistently suppress market hours. The growth of per capita consumer durables holdings identified as recreational goods – the empirical counterpart to leisure capital – shows strong cyclicality, as shown in Figure 3. The model does not have the strong pro-cyclical changes in stocks: Rental rates tend to be low in recessions which would encourage capital holdings.

6.5 Robustness

Several of the parameters were assigned with uncertainty on their true value. This section examines the robustness of the results to changes in capital share in leisure production (α^l) and the consumption aggregator parameters η and ψ. Changing these parameters has no impact on the qualitative findings: The time series of model wedges is the same across values. The size of wedge movements are affected, but the quantitative impact is small. The uncertainty about these values do not overturn the results.

Doubling the capital share in leisure production (α^l) to 0.16 (and adjusting ϵ to 1.39 to keep the Frisch elasticity at 0.75) increases the impact of leisure capital somewhat. The fall in the labor wedge from 1984 to 2000 becomes 25 percent versus 33 percent in the baseline. The increasing stock of leisure capital dampens this decline since it is more important in the labor-leisure decision with a higher value of α^l. Therefore, the model predicts an increasing difference in the labor wedges with and without leisure capital over the sample period.

Moro et al. (2015) survey the literature on the value of the elasticity between market

[3]The reason for falling labor participation during this period has been a source of controversy. Mulligan (2012) argues non-tax labor market distortions increased during this period. Juhn, Murphy & Topel (2002) cite increasing disability claims.

and household consumption. They find a range of 1.49 to 2.30, which that implies η is between 0.32 and 0.56. A lower value of η – non-market consumption is less substitutable – reduces the impact of household production on the model's predicted wedge. If η is 0.32, the model wedge falls 36 percent from 1984 to 2000. If η is 0.57, this value becomes 28 percent.

Increasing the weight on non-market consumption $1-\psi$ also further dampens the 1980s fall in labor wedges. Setting ψ to 0.5 reduces the fall in the 1984-2000 fall in labor wedge to 24 percent.

Higher values of η and ψ make the decline in household production due to marketization less important to consumption growth. The model more closely resembles the model without non-market sectors, so the implies wedges are also more similar. However, the model with non-market sectors is much closer to empirical labor tax wedges in all these robustness checks.

7 Conclusion

U.S. time use patterns have changed over the last century in ways that are difficult to model consistently. In this paper, I show that including non-market uses of time in production improves the labor supply predictions of macro models and resolves many of these inconsistencies in a unified framework.

It is a step toward fully accounting for the value of people's time. The value of market and home production time both have large literatures. Leisure, while not completely ignored, has the least study despite households allocating more time to it than home production. The analysis shows that the value of leisure has been increasing more than looking at leisure hours alone would suggest.

A Equations

This section reports the Φ_i in Equation 4.1 and Equation 5.1.

$\Phi_1 = \frac{\alpha^l q^m_{t-1}}{(1-\alpha^l) R^m_t \beta}$

$$\Phi_2 = \frac{\eta+(1-\eta)\alpha^h}{\phi(1-\alpha^l)}$$

$$\Phi_3 = \frac{\alpha^m\beta}{1-\alpha^m}\left[\frac{R^m_{t+1}\beta(1-\alpha^m)}{q^m_t\alpha^l}\right]^{\alpha^l(\epsilon-1)}$$

$$\Phi_4 = \left[\frac{\beta R^m_{t+1}}{q^m_t}\right]^{\frac{1}{\epsilon}}\left[\frac{q^l_t q^m_{t-1}R^m_{t-1}}{q^l_{t-1}R^m_t q^m_{t-2}}\right]^{\alpha^l(\epsilon-1)}\frac{q^m_t}{R^m_{t+1}}\left[\frac{\alpha^l}{1-\alpha^l}-\frac{\alpha^m}{1-\alpha^m}\right]$$

$$\Phi_4' = \left[\frac{\beta R^m_{t+1}}{q^m_t}\right]^{\frac{1}{\epsilon}}\left[\frac{q^l_t q^m_{t-1}R^m_{t-1}}{q^l_{t-1}R^m_t q^m_{t-2}}\right]^{\alpha^l(\epsilon-1)}\frac{q^m_t}{R^m_{t+1}}$$

$$\Phi_5 = \frac{\alpha^m q^m_t w^m_{t+1}}{(1-\alpha^m)w^m_t R^m_{t+1}}$$

$$\Phi_6 = \left[\frac{(1-\alpha^h)(1-\eta)}{\phi(1-\alpha^l)}\right]^{\frac{1}{\alpha^l(\epsilon-1)}}\left[\frac{\alpha^l q^m_{t-1}}{R^m_t(1-\alpha^l)}\right]$$

$$\Phi_7 = \frac{1}{1-\alpha^m}$$

B Data

Consumption, GDP NIPA table 1.1.5, accessed February 27, 2016.

NIPA prices NIPA Table 1.1.9.

Depreciation Detailed Consumer Durables Tables 8.1 and 8.4, 2015 edition.

Capital prices NIPA Table 1.5.4, lines 7 and 26.

Market hours, population Cociuba et al. (2012), updated to 2011 by McGrattan & Prescott (2012), updated to 2014 using CPS data.

Home production "Restrictive household production" measure from Bridgman (2016*b*), 2011 to 2014 updated using Bridgman (2016*a*). The durables included are half of autos, home furnishings, medical appliances and telecommunications equipment, Detailed Consumer Durables Table 8.1, lines 2, 6, 19 and 22.

Taxes From McDaniel (2011). I set 2014 rates equal to 2013 rates.

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