Is Productivity on Vacation? The Impact of the Digital Economy on the Value of Leisure

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Abstract

Many recent digital innovations (like video games) augment the value of leisure time, which is not captured by GDP. Therefore, the productivity impact of such innovations may be understated. I develop the theoretical foundations for measuring the value of leisure when it is produced using the household's leisure time and recreational durable goods. I apply this framework to estimate the value of U.S. leisure from 1948 to 2016. While the value of leisure is large, it has become less important over time. I find that productivity growth of leisure time has slowed in the digital era. Household stocks of digital goods are small, so have relatively little impact on leisure value. I conclude that mismeasurement due to household digital goods is not a first order cause of the recent productivity slowdown.

JEL classification: E2, J2

Keywords: Leisure; Consumer durables; Total income; Household production; Productivity.

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1 Introduction

Despite the wide adoption of the internet and digital goods, productivity growth after 2004 has been weak. Syverson (2017) estimates that this slowdown lowered U.S. GDP by $2.9 trillion between 2005 and 2015. Some economists argue that GDP has difficulty measuring the impact of the digital economy and this slow growth of productivity is a measurement problem (Ahmad & Schreyer 2016, Hulten & Nakamura 2017, Diewert & Fox 2017).

National accounts exclude the value of non-market production, largely for practical reasons. A potential channel for the digital economy to be mismeasured is that many recent high tech innovations, such as smart phones, augment the value of leisure time. They require a great deal of a consumer's time, an aspect sometimes referred to as the "attention economy" (Brynjolfsson & Oh 2012). Aguiar, Bils, Charles & Hurst (2017) give such innovations a central role in the labor decisions of young men. Therefore, the full value of digital innovations may not be captured by the national accounts[1]. Previous work has shown that household production would change output and productivity significantly if it were included in output[2]. Leisure, though it is the largest single category of time use, has not been studied in the same detail.

There is an opposing force to this argument. People may trade off market produced leisure services for non-market leisure. Under this scenario, some GDP growth would reflect the reallocation of non-market to market activity (Cruz & Raurich 2016). Costa (1997) documents a long run increase in market purchases of leisure goods and services. This marketization has been an important force in household production, another non-market use of time (Bridgman, Duernecker & Herrendorf 2018).

Which of these forces dominates is a quantitative question. I examine the value of all

[1] Another interpretation is that the impact of these innovations is not mismeasured, but have not yet had an opportunity to have be adopted sufficiently to have a productivity effect (Brynjolfsson, Rock & Syverson 2017).

[2] There is a large literature on the measurement of household production, which is impossible to survey here. Estimates of the household sector's magnitude include Eisner (1989) and Landefeld & McCulla (2000) for the United States and Miranda (2014) for cross-country evidence.

uses of time – market, household production and leisure – a concept Becker (1965) referred to as total income. I use this framework to evaluate the value of recreational innovations for non-market uses. I begin by using the Diewert & Schreyer (2014) framework to develop the theoretical foundations of how to measure the value of leisure when it is produced using time and durable recreational goods. I show that the theoretically correct returns needed to impute the value of leisure can be found in the market. I solve a model assuming that leisure is produced by market firms to find the market prices that correspond to the returns to the factors of production. Using these theoretical results, I calculate value of leisure for the United States from 1948 to 2016.

I find that leisure is a large portion of total income. However, total income grows slower than GDP. Both leisure and household production have declined in importance relative to the market. The impact on growth rates is small. Nominal total income per hour grows 4.5 percent a year from 1948 to 2016, only slightly below the 5.0 percent for nominal GDP per hour. So while GDP misses a great deal of value, it has a relatively small effect on growth rates.

Leisure labor productivity, the real value of leisure produced per leisure hour, slowed during the digital era. The "missing productivity" scenario requires that the unmeasured productivity effect on leisure time both increased a great deal recently and did not increase much in the past. This is not the case. The expansion of recreational durables predates the personal computer. Between 1955 and 1975, households greatly expanded their stocks of recreational durables. The labor productivity effect of televisions, sporting goods and recreational vehicles during this period rivals the recent increase in digital goods.

The digital economy is unlikely to be a first order explanation of changes in leisure value, since the stock of internet devices owned by households is small relative to the value of leisure. It is negligible relative to the overall economy. Even if the stock of internet devices were underestimated, the degree of mismeasurement would have to be unrealistically large to have a quantitative effect on productivity.

This paper is part of a literature on the measurement of well-being outside of GDP.

There is concern that welfare comparisons based only on GDP may give misleading answers (Stiglitz, Sen & Fitoussi 2009, Diewert & Schreyer 2014, Jones & Klenow 2016, Corrado, Fox, Goodridge, Haskel, Jona-Lasinio, Sichel & Westlake 2017). Others have suggested using alternative frameworks to GDP to measure the impact of the digital economy (Hulten & Nakamura 2017, Diewert & Fox 2017). This paper contributes to that literature by deriving the theoretical basis for estimating the value of leisure.

A number of papers have included leisure production. Ngai & Pissarides (2008), Vandenbroucke (2009), Bridgman (2016*b*), and Boppart & Ngai (2017) examine changes in hours using models with leisure production. Other papers have considered the value of leisure as a combination of time and goods. 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) and Nakamura, Samuels & Soloveichik (2017) examine the value of "free" entertainment. Gronau & Hamermesh (2006) examine the time and goods intensity of household activities. 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). This paper uses a unified aggregate approach to total time use to examine productivity.

2 Model

This section lays out the methodology for the estimating the value of leisure. I present a model that shows the theoretical justification for the imputations used in the estimation. It uses the Diewert & Schreyer (2014) framework extended to include capital, as in Bridgman (2016*c*).

2.1 Environment

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

$$H_t^h + H_t^m + H_t^l \leq 1 \tag{2.1}$$

Market time earns a wage W_t^m.

The representative household's preferences over market and home consumption goods (C_t^m and C_t^h respectively) and leisure l_t and market produced leisure services C_t^l are represented by

$$\sum_t \beta^t [u(C_t^h, C_t^m, l_t + C_t^l) - v^m(H_t^m) - v^h(H_t^h)] \tag{2.2}$$

The u function represents the utility from consumption and the v^j functions for $j \in \{m, h\}$ represents the disutility to working. Home produced leisure and market leisure services are perfect substitutes. The functions u and v^j for $j \in \{m, h\}$ are differentiable and increasing.

Leisure is produced using leisure production time H_t^l and leisure capital K_t^l in the differentiable, constant returns to scale (CRS) function F^l

$$l_t = F^l(K_t^l, H_t^l) \tag{2.3}$$

Home consumption is produced using household capital K_t^h and labor. This labor consists of the household's home production hours H_t^h and the hours of hired household workers H_t^s. (The s superscript can be thought of as quantities of "servants.") The hired household worker wage is w_t^s. The technology for producing this consumption is given by the differentiable, CRS function F^h:

$$C_t^h = F^h(K_t^h, H_t^h + H_t^s) \tag{2.4}$$

The stand-in homeworker household only has preferences over the market good represented by the differentiable utility function $\sum \beta^t u^s(C_t^{m,s})$. These workers may provide $\overline{L}^s$ units of labor time to the home consumption sector and cannot save. Following Diewert & Schreyer

(2014), I simplify the analysis by limiting the choices the homeworker household makes. The imputation result would be unchanged if they had the same preferences and were allowed the full set of choices.

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

$$K_{t+1}^j = K_t^j(1 - \delta_j) + X_t^j \tag{2.5}$$

where X_t^j is investment and δ_t^j is depreciation. The rates of return are given by R_t^j.

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

$$C_t^m + \frac{C_t^l}{A_t^l} + X_t^m + X_t^h + X_t^l = F^m(K_t^m, H_t^m) \tag{2.6}$$

where A_t^l is the leisure services specific productivity factor. This factor allows the price of market goods and leisure services to differ.

There are one period bonds B_t. Bonds purchased in period $t-1$ pay the return $1 + R_t^b$ in the next period.

2.2 Equilibrium

Following Diewert & Schreyer (2014) and Bridgman (2016*c*), I derive the conditions for imputing the value of leisure by comparing the equilibrium when the household produces home consumption and leisure with the case where they are produced by market firms. I solve the model assuming that home consumption and leisure are produced by market firms. With this ownership structure, there are market prices for non-market inputs and outputs. This solution generates the expressions for bounds on the equivalent prices for the returns to the factors of production for leisure in terms of observable variables. This equilibrium is equivalent to the case where leisure is produced outside the market.

Under the alternative market structure where non-market quantities are produced in the market, leisure firms hire labor H_t^l at wage W_t^h and rent leisure capital K_t^l at rate R_t^l. The representative firm's problem is

$$\max p_t^l F^l(K_t^l, H_t^l) - W_t^l H_t^l - R_t^h K_t^h \tag{2.7}$$

where p_t^l is the leisure price. The price of market firm output is numeraire. The market consumption and investment firms' problem is to maximize

$$F^m(K_t^m, H_t^m) - W_t^m H_t^m - R_t^m K_t^m \tag{2.8}$$

Home consumption firms hire labor H_t^h and H_t^s at wages W_t^h and W_t^s respectively and rent household capital K_t^h at rate R_t^h. The home consumption firm's problem is

$$\max p_t^h F(K_t^h, H_t^h + H_t^s) - W_t^h H_t^h - W_t^s H_t^s - R_t^h K_t^h \tag{2.9}$$

where p_t^h is the household consumption price.

The household's budget constraint is

$$C_t^m + \sum_{j\in\{m,h,l\}} X_t^j + p_t^l(l_t + C_t^m) + p_t^h C_t^h + B_{t+1} =$$
$$W_t^m H_t^m + R_t^m K_t^m + W_t^l H_t^l + W_t^l H_t^l + R_t^l K_t^l + R_t^h K_t^h + B_t(1 + R_t^b) \tag{2.10}$$

It includes the market income from leisure and home production work and capital as well as the market purchases of leisure and home consumption.

The definition of equilibrium is standard.

Definition 2.1. *An equilibrium for given government policy* $\{B_t, R_t^b\}$ *is sequences of prices* $\{p_t^l, W_t^m, W_t^l, R_t^m, R_t^l\}$ *and quantities* $\{C_t^m, C_t^h, C_t^l, l_t, K_t^j, X_t^j, H_t^j\}$ *such that, given prices and policy,*

1. *Households choose* $\{C_t^m, C_t^h, C_t^l, l_t, K_t^j, X_t^j, H_t^j\}$ *to solve their problem;*
2. *Market firms choose* $\{C_t^m, C_t^l, K_t^m, X_t^j, H_t^m\}$ *to solve their problem;*
3. *Leisure firms choose* $\{l_t, K_t^l, L_t^l\}$ *to solve their problem;*
4. *Household worker households solves their problem;*
5. *The resource constraints (Equations 2.4, and 2.6) are satisfied.*

2.3 Imputation

The equilibrium conditions provide expressions that allow us to impute the value of leisure. I use the income approach to measure output, where value of leisure is imputed by calculating the returns of its inputs:

$$p_t^l F^l(K_t^l, H_t^l) = W_t^l H_t^l + R_t^l K_t^l \tag{2.11}$$

Therefore, we need measures of the leisure wage and return to capital to value leisure. I will show that prices observable in the market can be used to bound the correct prices for imputing the income to the factors of production.

Let $u_j(t)$ be the partial derivative of the utility function with respect to consumption type $j \in \{m, h, l\}$ and $v^{j\prime}(H_t^j)$ for $j \in \{m, h\}$ be the derivative of the disutility of work. Let $F_k^j(t)$ and $F_l^j(t)$ for $j \in \{m, l, h\}$ be the parallel objects for the production functions.

To make the household willing to save both by holding home capital and bonds, the net returns of both assets must be the same: $1 + R_t^l - \delta_l = 1 + R_t^b$. Therefore, the gross return to household capital is bond returns plus the depreciation of leisure capital.

$$R_t^l = R_t^b + \delta_l \tag{2.12}$$

For the household to allocate hours to both leisure and household production, the marginal returns to both activities are equalized. Therefore, in equilibrium $W_t^l = W_t^h - v^{h\prime}(H_t^h)/u_m(t)$. Since household and hired homeworker's time are perfect substitutes in home production, their wages are equal. Specifically, the home consumption firm's problem generates $W_t^h = W_t^s$. Therefore, the value of leisure time is $W_t^l = W_t^s - v^{h\prime}(H_t^h)/u_m(t)$, the home worker's wage less the disutility of working in household production.

An advantage of this result is that we do not need to know the market wage of non-participants. Most people who do not work in the market do some household production. Therefore, assuming those outside the market equate leisure and household production wages is plausible. Further, the evidence is that high market wage workers do not have higher wages in all activities. As shown in Bridgman et al. (2018), there are few returns to skill in household

production so the household worker wage is a reasonable proxy for non-participant's household production hours wage.

Finally, the model generates a price of leisure. Since market produced leisure services and home produced leisure are perfect substitutes, the market price of leisure services is also the price home produced leisure.

These price equations are derived from the solution to the problem where leisure is produced in the market, which is not how leisure works in reality. However, the solution is the same whether leisure is produced in the market or by the household. It is easy to show that the allocation in the market leisure equilibrium is equivalent to that with non-market leisure. (This is parallel to the equivalence result for household production in Bridgman (2016*c*).) Therefore, the market prices used to impute leisure are correct.

3 Value of Leisure, 1948-2016

In this section, I use the model to estimate the nominal value of U.S. leisure for the post-World War Two period. Based on the above analysis, we need estimates of the factors of production and their returns for leisure production that is not currently included in GDP. I begin by describing the data sources for the estimates and then report the results of the baseline estimates.

3.1 Leisure Wage

Most of the data required to impute the nominal value of leisure can be recovered directly. The stocks of leisure capital and leisure time are available from the fixed asset tables and time use surveys respectively. The return to leisure capital has a direct market equivalent, as shown in Equation 2.12. The one variable that cannot be recovered directly is the leisure wage. There is a disutility wedge between the observable household worker wage and the leisure wage. To proceed, we need to take a stand on the nature of this wedge.

I begin by examining what the model can tell us about this wedge using the general functional forms. I then examine the implications of particular functional forms.

The model allows us to bound the size of the disutility wedge. Equalizing the wages we can observe, we have:

$$W_t^m - W_t^s = \frac{v^{m\prime}(H_t^m) - v^{h\prime}(H_t^h)}{u_m(t)} \tag{3.1}$$

The gap between market and home worker wages (the right hand side of Equation 3.1) has increased since 1980 in the United States (Bridgman, Dugan, Lal, Osborne & Villones 2012). This implies the left hand side has also increased. Since there are multiple unknowns in a single equation, we cannot pin down what has happened to the gap between leisure and market wages, the household work disutility term $v^{h\prime}(H_t^h)/u_m(t)$. However, these data imply that the relative disutility of market work has been increasing.

We need to take a stand on a functional form to exactly pin down disutility. To get a sense of the quantitative size of disutility wedge, I look at wedge using a version of the preferences suggested in Greenwood, Hercowitz & Huffman (1988):

$$\log[(C_t^m)^{\alpha_u}(C_t^h)^{1-\alpha_u} + l(l_t) + C_t^l - \phi^m \frac{(H_t^m)^{1+\theta}}{1+\theta} - \phi^h \frac{(H_t^h)^{1+\theta}}{1+\theta}] \tag{3.2}$$

Let γ_j be the change in variable j. For example, $C_{t'}^m = \gamma^{C^m} C_t^m$. The change in the disutility wedge from time t to time t' is:

$$\frac{v^{h\prime}(H_{t'}^h)}{u_m(t')} \frac{u_m(t)}{v^{h\prime}(H_t^h)} = \left[\frac{\gamma^{C^m}}{\gamma^{C^h}}\right]^{1-\alpha_u} (\gamma^{C^h})^{\frac{1}{\theta}} \tag{3.3}$$

I feed the data on consumption and hours found in Bridgman (2016*b*) to find the change in the wedge between 1948 and 2016. I set $\theta = 0.6$, the parameter value used in Greenwood et al. (1988). I use $\alpha_u = 0.75$ based on Bridgman et al. (2012), who find that household production would have been between a third and a fifth of output if it were included in GDP. This exercise generates a disutility wedge that grows 30 percent between 1948 and 2016, or 0.4% a year.

As a baseline, I set the disutility wedge to zero ($v^h = 0$). The above evidence suggests that the wedge is flat to slightly increasing, so this assumption may not be far off of the reality.

To the degree that there is mismeasurement, it will tend to overstate the impact of leisure production. I will examine the robustness of the results when this assumption is weakened. The main result, that leisure value is important but not increasing relative to market production (GDP), is robust to alternative wages.

3.2 Estimates

I need to allocate time to the three uses in the model: market work, home production and leisure. I use the market and household production hours data in Bridgman (2016*a*). (See the Appendix for more detail on data sources.) For home production, he extends the estimates in Bridgman et al. (2012) and Bridgman (2016*c*). Market hours are an extension of those found in Cociuba, Prescott & Ueberfeldt (2012). I set per capita leisure hours to 5200 less market work and household production 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. 2018).

To measure household production, I use estimates from Bridgman (2016*c*). I use the restrictive definition of home production that excludes recreational capital to avoid double counting.

The capital in leisure production is the net stock of consumer recreational durables, drawn from BEA's fixed asset tables. The net rate of return for durables is the rate of return on household financial assets. Specifically, it is personal interest and dividend income drawn from the NIPAs divided by household financial assets from the Federal Reserve's Financial Accounts of the United States. To get the gross return, I add the value of depreciation from the fixed asset tables. Finally, I use the wage of home workers from the NIPA industry accounts to value leisure hours.

3.3 Size of Leisure Sector

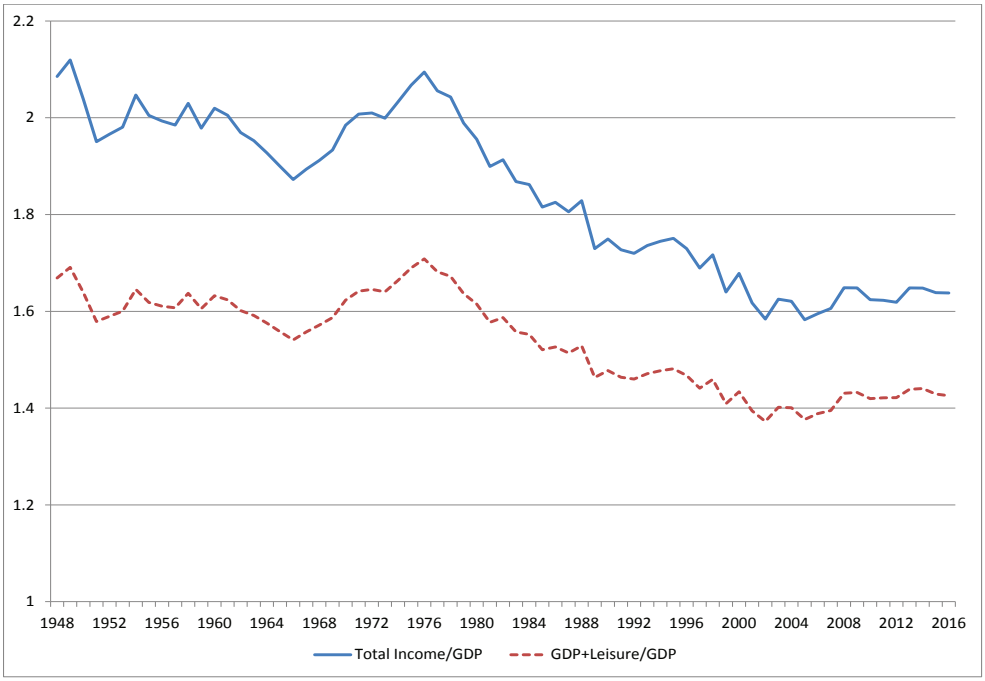
The estimates allow us to examine the value to total income, the economic value of all uses of time (Becker 1965). Total income combines the value of market activity, captured in GDP, with non-market time uses, leisure and home production. Figure 1 reports the ratio of U.S. total income to GDP. The value of non-market time is large compared to GDP, about twice as large until the 1980s. This ratio has fallen. This decline is due to falling importance of both household production and leisure production, though declining household production is more important. The ratio of the value of leisure plus GDP to GDP falls from 60 percent to 40 percent as large GDP. This fall (20 percentage points) is half the size of household production's 40 percentage points. While excluding the value of leisure leaves out a great deal of value, unmeasured leisure is becoming less important.

Most work, such as Aguiar & Hurst (2007) and Ramey & Francis (2009), looks only at hours. While the number of those hours and their total value are generally correlated, there are some differences. Figure 2 compares leisure's shares of both total income and hours. There is a slight increase in leisure hours share while the value share is decreasing.

A major reason for the difference between hours and output share is that relative value of a leisure hour has fallen as the gap between market and home worker wages has increased. As shown in Figure 3, home worker wages have fallen from 60 percent to 30 percent of market wages.

Leisure production has become more capital intensive. Figure 4 plots the labor share of in leisure production. It falls from 97 percent to 94 percent. Despite the increasing importance of capital, leisure is still a very labor intensive activity. In contrast, Bridgman (2016*a*) finds that household production is more capital intensive, with a labor share that fell from about 80 percent to 70 percent over the same period. The "Engines of Liberation" literature, such as Greenwood, Seshadri & Yorukoglu (2005), has given an important role to consumer durables in the organization of household production. Leisure production has a much narrower channel for these effects.

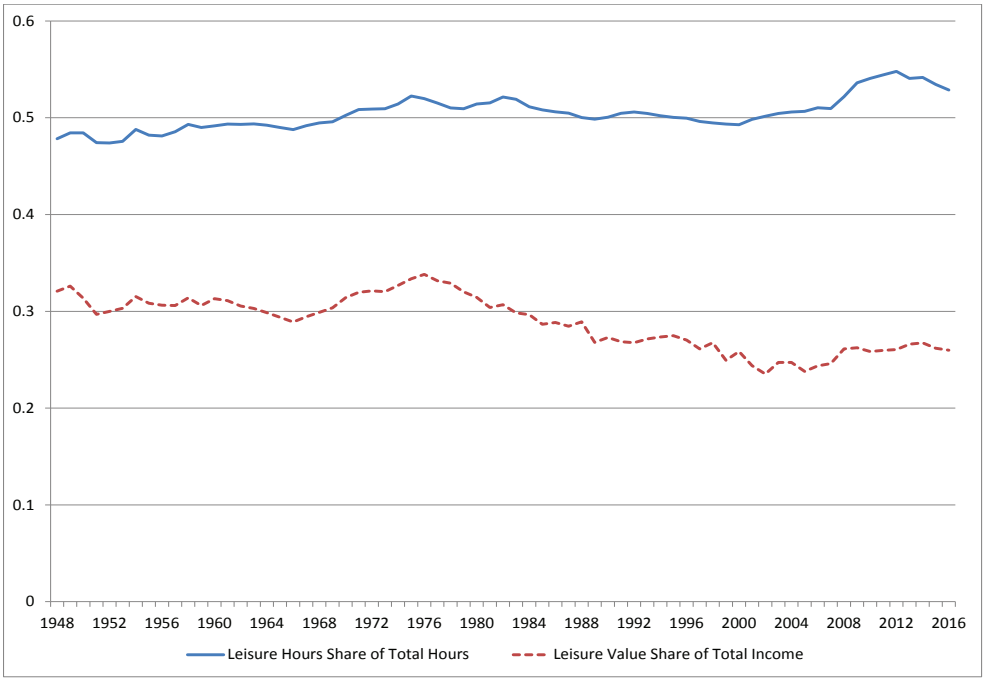
Figure 1: Ratio of Total Income and Leisure to GDP, 1948-2016



4 Can the Non-market Digital Economy Explain the Productivity Slowdown?

Productivity growth has been slower recently despite some significant innovations related to computer and communications technology. A literature has suggested that GDP does not fully capture the benefits of these innovations, understating productivity growth. Part of the benefit of these technologies is they make leisure more enjoyable, which will not be captured by GDP. Now that we have estimates of the value of leisure, we can address the issue of whether changes in this sector can account for recent slow productivity growth.

Figure 2: Leisure Shares of Total Income and Hours, 1948-2016

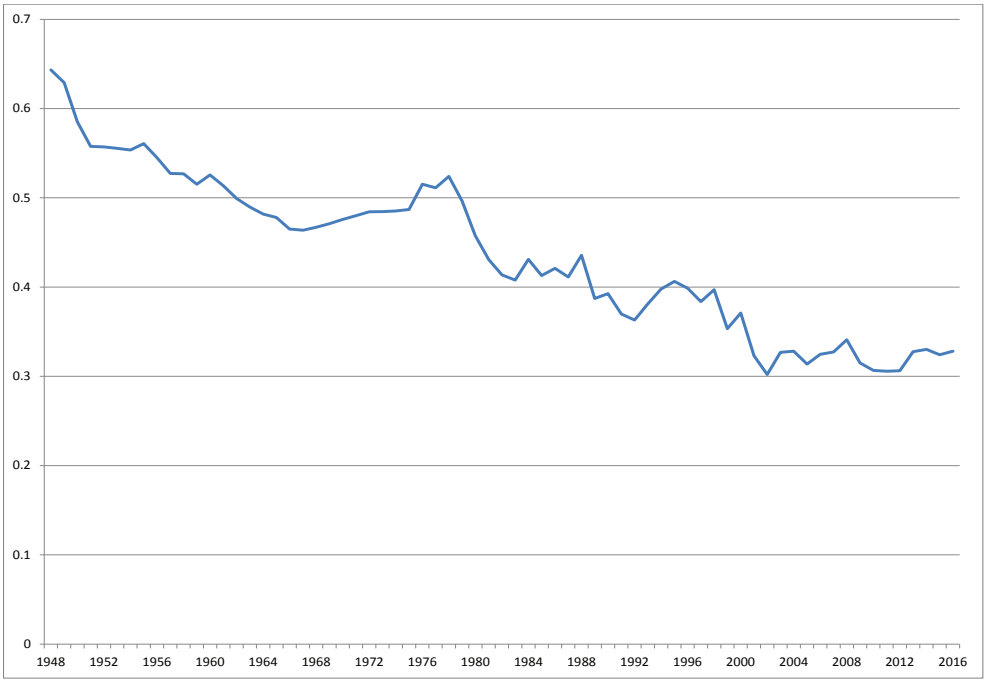


Syverson (2017) calculates that had labor productivity growth remained on its 1995-2004 trend, nominal GDP would be about $2.9 trillion higher in 2015. I estimate that the value of leisure grew by $2.9 trillion between 2004 and 2015[3]. The average growth rate of nominal total income per hour falls from 3.1 percent during 1995-2004 to 2.6 percent during 2005-2015. This half percentage point decline is less than the 1 percentage point fall in GDP per hour (from 4 percent to 3 percent).

Does this mean that impact of the digital economy on non-market production of leisure is a first order explanation for the productivity slowdown? To the degree that it does, the

[3]The value of leisure was $4.9 trillion in 2004 and $7.8 trillion in 2015.

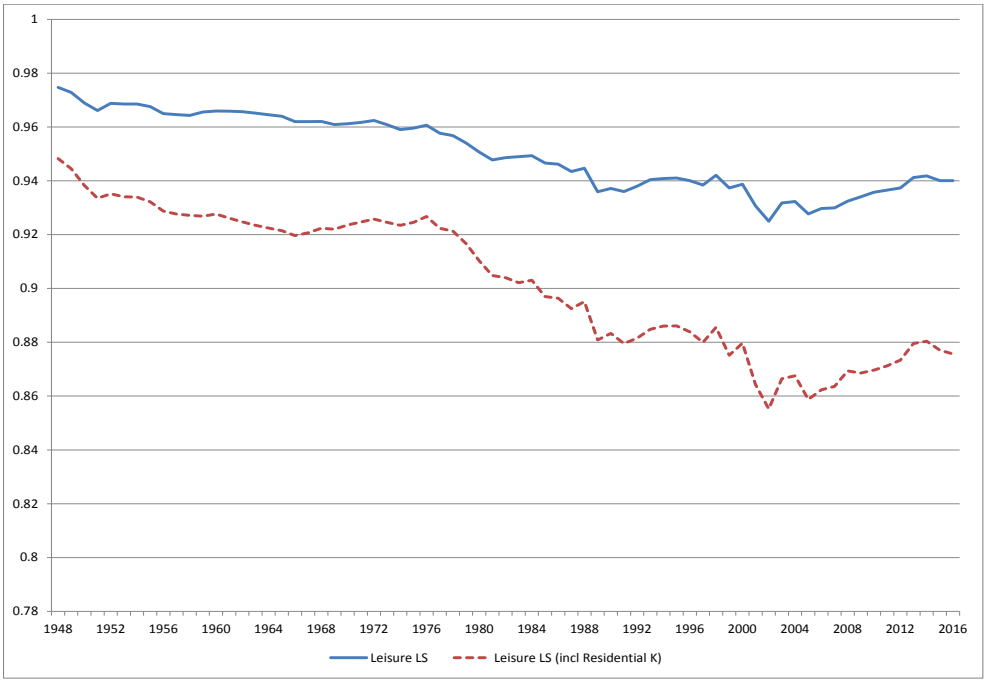
Figure 3: Ratio of Home Worker to Total Market Wages, 1948-2016



reasons do not align well with the technological optimists' story. The non-market sectors are *less* dynamic than the market sector. The labor productivity growth rate of leisure, measured as nominal leisure output per leisure hour, grew slower than nominal GDP per hour: 4.1 percent versus 6.2 percent annually. Nominal leisure labor productivity growth did accelerate in the 2005-15 period relative to the decade prior, increasing from 1.8 percent to 2.6 percent. However, this is much slower than the equivalent GDP per hour growth rates of 5.2 percent falling to 3.5 percent. The faster rate of leisure productivity growth in 2005-15 was still lower than slowdown GDP per hour growth.

These trends have little to do with high tech durable goods. Leisure production is

Figure 4: Leisure Labor Share, 1948-2016



very labor intensive. While there is capital deepening, but much of the change occurs prior to the introduction of computers and other high tech goods to the household. The share of recreational goods in total household consumer durables increases from 14 percent in 1955 to 21 percent in 1975. After this period, recreational goods share is flat to slightly increasing. It was 23 percent in 2014. While part of this increase is due to television, sporting equipment and recreational vehicles also show major increases. Strong economic growth (after a period of war and depression) and suburbanization are candidates for explaining why recreational goods demand is so strong during this period.

This definition of recreational goods is restrictive. In particular, it excludes telephones

since they are included in household production's capital stock. However, including communications equipment has little effect. The average capital share only increases slightly and the pattern is largely unchanged. The stocks of these goods that are held by the household are relatively small.

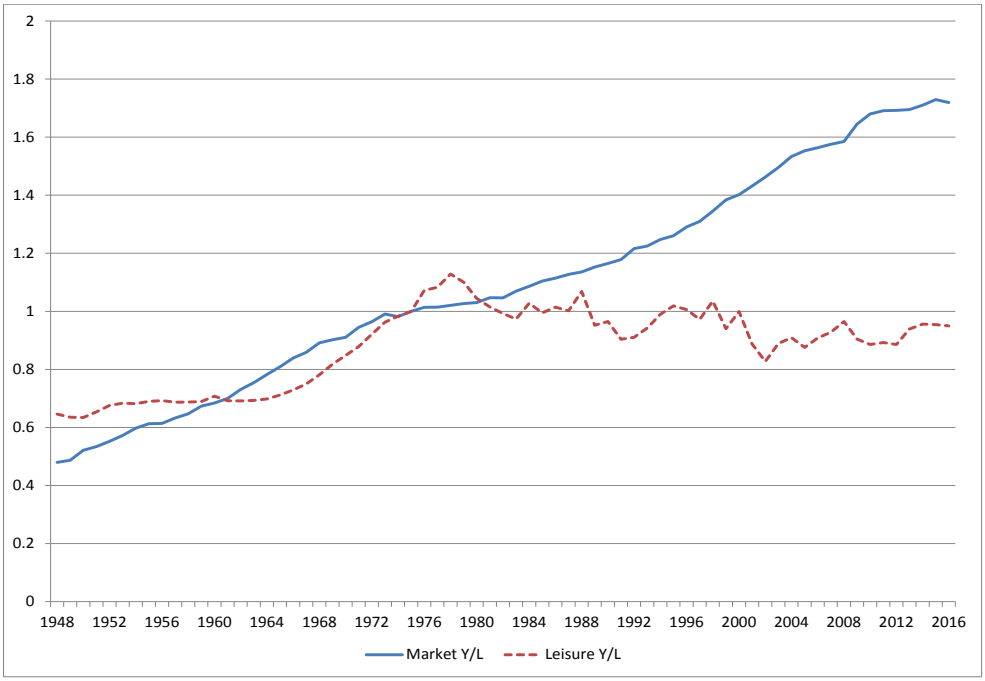
Another change would be to further expand the stock of leisure capital to include some portion of residential capital since houses can be used for recreational purposes. They form the "structures" capital that house the recreational durables "equipment" capital. To examine the impact of this change, I add 25 percent of housing services to the returns to leisure capital. Doing so does not change the pattern much. Further, these services are already in GDP so do not have a productivity effect on total income. In any case, the productivity optimists' argument focusses on new internet goods, not houses.

It is possible that the stock of internet devices were underestimated, as it is an industry with rapid change and many new goods. Increasing this stock would increase output since capital income is the stock multiplied by the rate of return. However, internet devices are already given significant quality adjustment and the stock owned by households is small relative to the overall economy. The degree of mismeasurement would have to be unrealistically large to have a quantitative effect on productivity. The results are consistent with the more pessimistic view in work such as Gordon (2015), Byrne, Fernald & Reinsdorf (2016), and Syverson (2017).

The above analysis only looks at nominal changes. To measure productivity, we need to deflate the imputed nominal household output to put it in real terms. As shown in the theory section, the correct price is the market price of leisure services. The closest analogue is the recreation services PCE deflator. I use this price index to deflate household leisure production to generate a real productivity series.

The real leisure productivity shows no increase after 2005. Figure 5 shows real labor productivity for the market and leisure sectors. The two grow at a similar rate until the 1980s, when leisure productivity growth flattens out. The 1980s slowdown corresponds to end of post-war capital deepening in leisure production.

Figure 5: Market and Leisure Labor Productivity, 1948-2016



For the optimistic scenario to work, unmeasured leisure productivity needs to have both increased a great deal recently and not increased much in the past. The second requirement is not met. The digital economy is not the only time recreational goods have augmented the value of leisure time. The expansion of household stocks of recreational durables in the post-war era also led to strong growth. So while the digital economy may be important right now, there were other changes in past that were as important. Therefore, the digital economy does not represent an unprecedented innovation to leisure production.

4.1 Are Wages Correct?

Value of leisure depends on getting wages right since it is a labor intensive activity. The baseline case ignored the disutility wedge in household production, so the theory suggests that there is mismeasurement in our measure of wage. However, this mismeasurement likely pushes relative leisure wage, hence output, *down*.

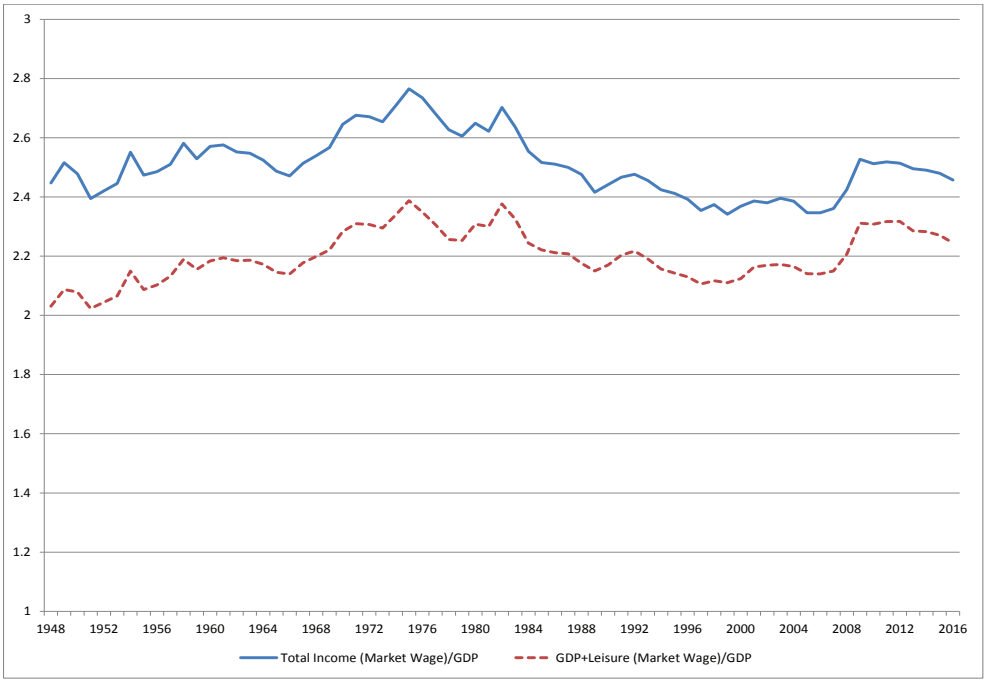
To get a sense of how quantitatively important this mismeasurement might be, I value leisure at the market wage. Despite the fact that market wages are much higher and grow faster than home workers wages, they do not increase growth much. As seen in Figure 6, leisure still falls relative to market production in the 1980s although the fall is less pronounced compared to the baseline case. The difference is not large enough to account for the missing productivity, even for this exercise which significantly overestimates the leisure wage.

This pattern of wages is not universal. Bridgman et al. (2018) finds that home worker wages in Western Europe do not generally follow the U.S. pattern, which suggests a larger role for leisure in those countries. This would echo their finding that their household production sectors are larger. I leave it to future work to apply this methodology to other countries.

5 Conclusion

National accounts exclude the value of non-market production. Many of the recent innovations, such as smart phones, augment the value of leisure time so the full value of such innovations may not be captured by the national accounts. Therefore, the productivity impact of such innovations will be understated. I examine this question examining all uses of time: market, household production and leisure. I develop the theoretical foundations of how to measure the value of leisure when it is produced using time and recreational durable goods. I then apply this framework to estimate the value of U.S. leisure from 1948 to 2016. While the value of leisure is large, unmeasured leisure has declined in importance. The stock of internet devices owned by households is small relative to the overall economy. Household digital goods do not

Figure 6: Ratio of Total Income and Leisure (Market Wage Valuation) to GDP, 1948-2016



have a quantitatively important effect on productivity.

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6 Data Documentation

This appendix describes the data sources.

GDP NIPA Table 1.1.5 (August 28, 2017 Edition)

Recreational Durables NIPA Tables 8.1/8.4 (August 23, 2017 Edition), sum of lines 11 (Recreational durables), 21 (Luggage) and 0.25 of line 2 (Autos).

Hours Bridgman (2016*b*). Market hours (derived from CPS and Department of Defense data) updated from Cociuba et al. (2012) using McGrattan & Prescott (2012). Household production hours updated from Bridgman (2016*a*).

Homeworker Wage Compensation and full time equivalent (FTE) employees of private households, NIPA tables 6.2 and 6.5 for private households (SIC) and other services ex. Govt (NAICS). Converted to hourly compensation by assuming a FTE works 2080 hours annually. FTE employees data for 2000 on come from unpublished estimates obtained from BEA.

Market Wage Labor compensation (NIPA Table 1.10, line 2; August 30, 2017 Edition) divided by market hours.

Rate of Return The rate of return on HH financial assets using data from the Flow of Funds. Specifically, personal income receipts from assets (NIPA table 2.9 line 5) over total financial assets of the household less equity in non-corporate business (Table B.100 series FL154090005-FL152090205).