Cheap Thrills: the Price of Leisure and the Global Decline in Work Hours*

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Abstract

The real price of recreation goods and services has fallen dramatically over the last century. At the same time, hours per worker have also been on a steady decline. As recreation goods make leisure time more enjoyable, we investigate if the fall in their price has contributed to the decline in work hours. Using aggregate data from OECD countries, as well as disaggregated data from the United States, we provide evidence that the two are strongly related. To identify the effect of recreation prices on hours worked, we use variation in the bundle of recreational goods across demographic groups to instrument for the changing price of leisure faced by these groups over time. We then construct a macroeconomic model with general preferences that allows for trending relative prices and work hours along a balanced growth path. We estimate the model and find that the decline in recreation prices can explain a large fraction of the global decline in work hours.

JEL Classifications: E24, J22

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1 Introduction

Hours worked have declined substantially over the last hundred years. Nowadays, American workers spends on average two thousand hours a year at work, while their 1900 counterparts worked 50% more. Over the same period, technological progress has increased labor productivity and wages, and so the decline in hours is often attributed to an income effect through which richer households choose to enjoy more leisure time. Indeed, Keynes (1930) prophesized that "the economic problem may be solved [...] within a hundred years" and that therefore there would be no need to work long hours to satisfy one's desire for consumption.

Another important change occurred over the same period, however. New technologies such as televisions and the internet have brought a virtually unlimited trove of cheap entertainment at consumers' fingertips. The impact of these technologies is clearly visible in the price data. For instance, the Bureau of Labor Statistics (BLS) documents that the (real and quality-adjusted) price of a television set has fallen about 1000-fold since the 1950s, while computers are about fifty times cheaper than they were in the mid-1990s. Similarly, the inflation-adjusted price of admission to a (silent, black and white) movie in 1919 is roughly equal to the current cost of a monthly subscription to a video streaming service providing essentially unlimited access to movies and television shows. While these are only examples, the U.S. aggregate price index tracking recreational goods and services has also declined dramatically since 1900, falling by more than half in real terms. Did this large decline in the price of leisure impact the observed increase in its quantity?

In this paper, we investigate how much of the decline in hours worked can be attributed to rising wages, and how much comes from the decline in recreation prices. Answering this question has important implications for our understanding of the labor market and, in particular, for making predictions about how much people will work in the future. If the decline in hours can be mostly attributed to the income effect, then the weakening growth in median income might lead to a slowdown in the decline in work hours (Mishel et al., 2012). If instead the movement in recreation prices is driving the downward trend in hours, we can expect the trend to continue as new technologies keep making leisure cheaper and more enjoyable. In addition, taking into account the impact of recreation prices on hours worked can lead to a better understanding of the elasticity of labor supply to changes in wages—a key parameter for the design of multiple government policies.

We begin by providing an overview of the data. For the United States, we consider three metrics that provide information about the decline in work hours.[1] Using data from the Census and the BLS, we first show that hours per worker have declined at a steady pace since 1900, with the exception of large movements around the Great Depression and the Second World War. Hours per capita have also fallen over that period, although the decline is concentrated in the first part

[1] Similar evidence is presented in a number of studies, including Owen (1970), Lebergott (1993), Fogel (2000), Greenwood and Vandenbroucke (2005), and Boppart and Krusell (2020).

of the twentieth century. After 1950, the large increase in female labor force participation has kept that measure mostly flat. In contrast, the decline in male hours per capita has continued unabashed over that period. Finally, we plot data from the American Time Use Survey that show that self-reported leisure time has also been increasing, for both men and women, since the 1960s (Robinson and Godbey, 2010; Aguiar and Hurst, 2007b).[2] This last piece of evidence confirms that the decline in market work hours is not simply an artifact of a reallocation toward housework. The trends observed in the U.S. are also visible in other developed countries. We look at the evolution of work hours in 42 OECD countries and find that hours per worker have declined virtually everywhere, while hours per capita have fallen in 34 countries.

This decline in work hours in the United States over the last 120 years was accompanied by a large, well-documented, increase in wages, as well as a large decline in recreation prices. We extend early work by Owen (1970) with data from the Census and the BLS to show that the real price of recreation goods and services has been steadily decreasing since 1900, at a pace of about -0.75% per year. This trend is also clearly visible in our multi-country sample. Indeed, real recreation prices have fallen in *all* the countries that we consider, with an average annual decline of -1.48%. We conclude from these data that the decline in work hours and real recreation prices are widespread phenomena that affected a broad array of developed countries.

To explore the impact of changes in wages and recreation prices on hours worked, we perform a series of cross-country regressions and show that a decline in recreation prices is significantly associated with a decline in hours per capita. This effect is also economically important: a one percentage point decline in the growth rate of recreation prices is associated with about a 0.29 p.p. decline in the growth rate of hours. That relationship remains when various controls, such as the increase in female labor force participation, are included. These regressions also inform us about the impact of hourly wages on hours worked. But in almost all the specifications that we consider, the effect of wages is statistically indistinguishable from zero.

In order to obtain causal estimates of the impact of wages and recreation prices we turn to detailed individual-level data from the U.S. Census. While our main focus is on aggregate variables, one key advantage of using these disaggregated data is that they allow us to construct two instrumental variables to tackle potential endogeneity issues. In the spirit of Bartik (1991), we construct a first instrument, for wages, that uses location-specific industry employment shares to tease out fluctuations in local wages that are driven by national movements. We also construct a second instrument, this time for recreation prices, using variation in the type of recreation goods and services that are consumed by different demographic groups. Using data from the Consumer Expenditure Survey, we document that, for instance, individuals without a high-school diploma con-

[2] Ramey and Francis (2009) also provide evidence that leisure time per capita has increased between 1900 and 2005. Their estimates are somewhat smaller than those of Aguiar and Hurst (2007b), mostly because of a different classification of activities.

sume a disproportionate amount of "Audio and video" items, while those with more than a college education consume relatively more of "Other services", which includes admissions, fees for lessons, club memberships, etc. Importantly, the national price of these items has diverged markedly in our sample, creating substantial variation in the price of the recreation bundles consumed by different demographics. We use a shift-share approach to construct an instrument that takes advantage of this variation. Using these two instruments, we find a strong positive effect of recreation prices on hours worked, suggesting that the relationship visible in the cross-country data might have a causal interpretation. We also find a strong negative impact of wages on hours worked, so that the income effect seems to dominate the substitution effect in this sample.

We also describe how changes in the price of different recreation items might be important to account for the rise in leisure inequality that has been observed since 1985 (Aguiar and Hurst, 2009). Indeed, leisure time has grown the most among groups that have experienced the slowest growth in wages (e.g. the less educated), so that the income effect alone would be unable to explain their relative increase in leisure time. In contrast, the price of recreation items that they consume has declined significantly over the same period which could have pushed these household to consume more leisure, in line with the data.[3] In contrast, the real relative price of recreation items consumed by more-educated households has been increasing, but so has their wages. As a result, their leisure time has been more stable during the last decades.

In order to further refine and interpret the reduced-form evidence, we construct a macroeconomic model in which recreation prices and wages can affect labor supply decisions. At the heart of our analysis is a household that values recreation time and recreation goods and services, as well as standard (i.e. non-recreation) consumption goods. To be consistent with well-known long-run trends, we build on the standard macroeconomic framework of balanced growth and assume that all prices and quantities in the economy grow at constant, but potentially different, rates. Importantly, and in contrast to the standard balanced-growth assumptions, we do not assume that hours worked remain constant over time, but instead allow them to also grow (or decline) at a constant rate.

For our analysis to be as general as possible, we follow the approach of Boppart and Krusell (2020) and keep the household's preferences mostly unrestricted, only requiring that they be consistent with a balanced-growth path. We characterize the general form that a utility function must take in this setup, and show that it nests the standard balanced-growth preferences with constant hours of King et al. (1988), as well as the more general preferences of Boppart and Krusell (2020) that allow for hours to decline over time through the income effect of rising wages. In addition, we show that in the class of economies we study the growth rates of hours, recreation consumption and non-recreation consumption are log-linearly related to those of the wage rate and the real price

[3] Consistent with this interpretation, Aguiar et al. (2017) show that the increased leisure time of young men is strongly associated with their consumption of online streaming and video games.

of recreation items.

Our theoretical model has several key advantages when it comes to making contact with the data. First, since we keep the household's preferences quite general, our empirical strategy does not hinge on a specific utility function, but instead remains valid under several functional forms that have been proposed in the literature. Second, there is no need to fully specify the production sector of the economy. We only need wages and recreation prices to grow at constant rates for our analysis to be well-grounded. Third, the system of equations derived from the model can be estimated using standard techniques and allows for a straightforward identification of the key structural parameters of the economy. Finally, the model provides a set of cross-equation restrictions that impose more structure on the estimation compared to reduced-form techniques. In particular, these restrictions allow us to use consumption data to discipline the estimation of the effect of recreation prices on hours worked.

We estimate the structural relations implied by the model using both our multi-country and household-level samples. In both cases, we find that a decline in recreation prices leads to a large and significant increase in leisure time. Rising wages are also strongly associated with a decline in hours worked. These effects survive to using our two earlier instruments in the estimation. Finally, we perform back-of-the-envelope calculations and find that the fall in the price of recreation goods and services, on its own, can explain a large fraction of the decline in hours worked observed in the data.

Literature

Our empirical results update and extend an early analysis by Owen (1971) who finds strong evidence of complementarity between leisure time and recreational goods and services in the United States (see also Gonzalez-Chapela, 2007). Owen attributes one quarter of the decline in hours worked over the 1900-1961 period to the declining price of recreation items, and the remaining three quarters to the income effect of rising wages. An important difference with our approach is that we construct Bartik-like instruments to handle endogeneity issues. We also provide a general balanced-growth model to guide our empirical exercises.

Our findings are also consistent with Aguiar et al. (2017) who show that the increased leisure time, in particular among young men, is strongly associated with the consumption of leisure goods and services made available due to the advent of cheap new media technologies, such as online streaming and video games. Bick et al. (2018) find that the relationship between hours and labor productivity is strongly negative across developing countries, but that it is essentially flat across individuals in developed countries. Our findings that both the income effect and heterogeneous changes in the price of households' recreation bundles are at work can help make sense of that data.

Vandenbroucke (2009) evaluates the impact of recreation prices in a static model with worker heterogeneity. In a calibration exercise over the 1900-1950 period, he finds that 82% of the decline in hours worked can be attributed to the income effect and only 7% to the declining price of recreation goods. Kopecky (2011) focuses on the reduced labor market participation of older men and argues that retirement has become more attractive due to the decline in the price of leisure. In a recent paper, Fenton and Koenig (2018) argue that the introduction of televisions in the United States in the 1940s and 1950s had a substantial negative effect on labor supply decisions, especially for older men.

Our main theoretical result generalizes recent work by Boppart and Krusell (2020) who characterize the class of preferences that are consistent with balanced growth and declining work hours. We extend their preferences to include recreation goods that are complement with leisure time. As a result, we can jointly investigate the importance of wages and recreation prices as drivers of the decline in work hours.

Greenwood and Vandenbroucke (2005) consider a static model of the role of technological changes in the long-run evolution of work hours through three channels: rising marginal product of labor (the income effect), the introduction of new time-saving goods (the home production channel) and the introduction of time-using goods (the leisure channel). The second effect, in particular, is important for accounting for the entry of women into the labor force, which makes the long-run decline of work hours per person (rather than hours per worker) less pronounced.

Ngai and Pissarides (2008) construct a model in which leisure time rises on a balanced growth path due to a complementarity between leisure and "capital goods" (such as entertainment durables), as well as marketization of home production. Building on this, Boppart and Ngai (2017) provide a model where both leisure time and leisure inequality increase along a balanced growth path due to the growing dispersion in labor market productivity. In recent work, Boerma and Karabarbounis (2020) argue that the rising productivity of leisure time combined with cross-sectional heterogeneity in preferences (or "non-market productivity") is responsible for these trends. Our work departs from the existing literature in several ways. On the theoretical side, we keep the preferences of the household as general as possible. On the empirical side, we investigate the impact of recreation prices in both aggregate data in a broad cross-section of countries and in disaggregated data in the U.S. Most importantly, we use instruments to tease out the causal impact of recreation prices and the wage.

The next section provides an overview of the data as well as reduced-form exercises. We then introduce the model and provide our main theoretical result. Finally, we estimate the structural relationships derived from the model. The last section concludes.

2 Reduced-form empirical evidence

We begin by presenting the relevant data for the United States and a cross-section of countries. We document three important trends that hold in almost all the countries in our sample over the last decades: 1) hours worked have fallen, 2) the price of recreation goods and services has declined substantially in real terms, and 3) real wages have been increasing. We also present reduced-form evidence to show that the decline in work hours is strongly associated with the decline in recreations prices. To avoid burdening the text, we keep the precise data sources and the steps taken to construct the datasets in Appendix A.

2.1 The global decline in work hours and recreation prices

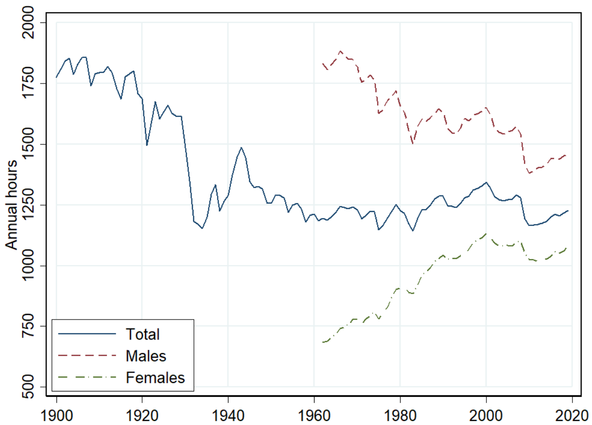
Evidence from the United States

Figure 1 shows the evolution of work hours, wages and recreation prices in the United States. The solid blue line in panel (a) shows how hours worked per capita have evolved between 1900 and 2019. Over the whole period, hours have fallen significantly from about 1750 annual hours per adult person in 1900 to about 1200 hours per person today.[4] While the figure shows an overall reduction in hours, all of the decline actually took place before 1960. But these aggregate statistics are somewhat misleading as they conceal substantial heterogeneity between men and women, whose hours are shown in red and green in panel (a). As we can see, the second half of the twentieth century saw a large increase in women's hours, presumably due to the rise in labor force participation, which clearly contributed to the stagnation of the aggregate working hours per capita data.[5] At the same time, male hours per capita have kept declining. In the more recent period, between 2000 and 2019, hours have declined for both men and women.

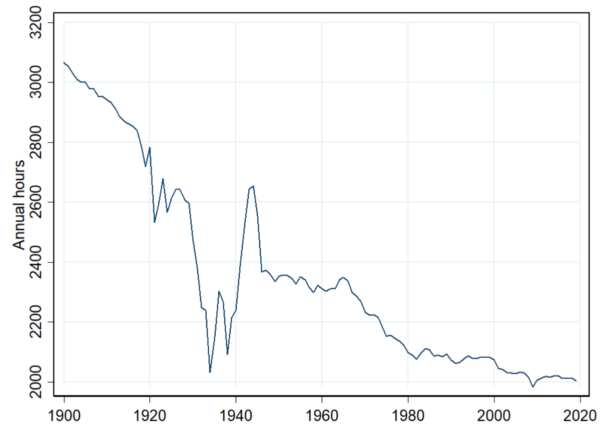
The evidence in panel (a) might suggest that women are working much more in 2019 than in 1960, but the figure only reports hours worked in the marketplace. Total work hours, which also include home production, have been declining since at least the 1960's for both men and women. To show this, we follow Aguiar and Hurst (2007b) and Aguiar et al. (2017) and use the American Time Use Survey to construct measures of market work, total work (including market work, home production and non-recreational childcare), and leisure for men and women between 16 and 64 years old (excluding full-time students). These series are presented in Figure 2. Between 1965 and 2017, total annual work hours have declined by 416 (8.0 hours per week) for women and by 502

[4] Here, we define adults as individuals above 20 years old. The trends are similar if we divide hours by the population older than 15 or the working age population (which we define as 25-64 years old) instead.

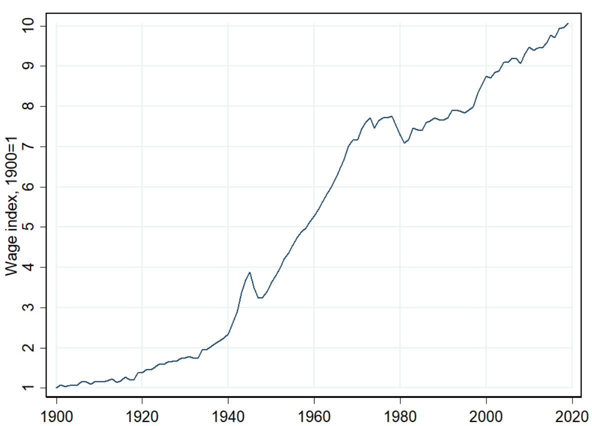
[5] This increase in female labor force participation is well documented and was driven by several factors. Many women were probably kept away from market work because of discriminatory social norms. As these norms evolved, the stigma of women in the labor force faded and female participation increased. In addition, technological improvements made it easier to perform nonmarket work—mostly done by women—leaving more time for market work (Greenwood et al., 2005). Goldin and Katz (2002) also document that the adoption of contraceptives might have affected women's decisions to pursue higher education.



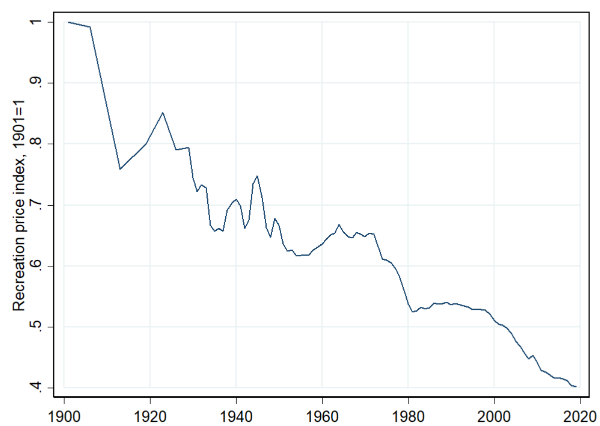
(a) Hours per capita



(b) Hours per worker



(c) Real wage



(d) Real recreation price

Panel (a): Annual hours worked over population (20 years and older). Source: Kendrick et al., 1961 (hours, 1990-1947); Kendrick et al., 1973 (hours, 1948-1961); Carter et al., 2006 (population, 1900-1961); ASEC (total, male and female hours per capita, 1962-2018). Panel (b): Annual hours worked over number of employed. Source: Bureau of the Census, 1975 (1900-1947); FRED (1947-2018). Panel (c): Real labor productivity. Source: Kendrick et al., 1961 (real gross national product divided by hours, 1900-1928); BEA and BLS (real compensation of employees, divided by hours and CPI, 1929-2018; retrieved from FRED). Panel (d): Real price of recreation goods and services. Source: Owen, 1970 (real recreation price, 1900-1934); Bureau of the Census, 1975 (real price of category 'Reading and recreation', 1935-1966); BLS (real price of category 'Entertainment', 1967-1992); BLS (real price of category 'Recreation', 1993-2018). Series coming from different sources are continuously pasted.

Figure 1: Hours, wages and recreation price in the U.S.

(9.7 hours per week) for men. According to that metric, women work substantially less now than fifty years ago.[6]

The decline in hours worked is also clearly visible when looking at hours per worker, instead of per capita. These data are presented in panel (b) of Figure 1. Except for large fluctuations around the Great Depression and the Second World War, that measure has been on a steady decline from more than 3000 annual hours per worker in 1900 to about 2000 today.[7]

What are the drivers behind this long-run decline in hours? Clearly, people are now richer than in 1900 and it might be that at higher income levels they prefer enjoying leisure to working. Indeed, panel (c) of Figure 1 shows that real hourly wages have gone up ten-fold since 1900. Theoretically, this tremendous increase in wages could lead to an increase in labor supply, if the standard substitution effect dominates, or to its decline, if the income effect dominates instead.

Like the benefit of working, the cost of enjoying leisure has also undergone a massive change over the last century. To show this, we plot in panel (d) of Figure 1 the *real* price of recreation goods and services since 1901.[8] Items in that category generally follow the BLS classifications and include goods and services that are associated with leisure time, such as video and audio equipment, pet products and services, sporting goods, photography, toys, games, recreational reading materials, and recreation services (such as admission to movies, theaters, concerts, sporting events, etc.).[9] As we can see, these prices have experienced a steep decline, falling by about 60% in real terms since 1901. If these goods and services are complement to leisure time, a decline in their price would incentivize households to consume more leisure. As a result, they could play an important role in the decline in hours worked.

Evidence from other countries

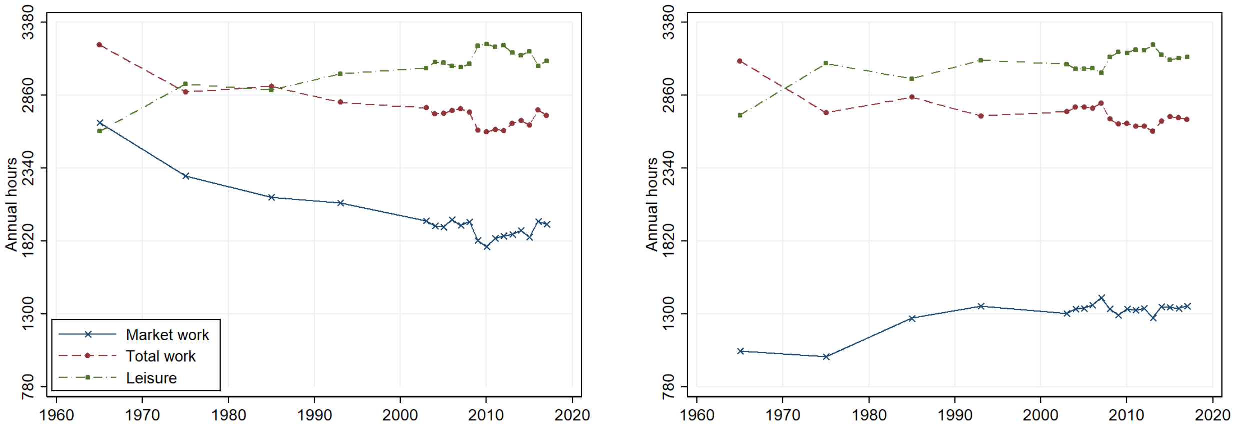
The trends observed in the U.S. economy are also visible in international data. To show this, we gather data on real recreation prices and wages from a variety of sources, such as the OECD, Eurostat and national statistical agencies. The OECD and Eurostat track the price of "Recreation and culture" items which we use as our main recreation price index. This category includes items such as audio-visual, photographic and information processing equipment, reading materials, package holidays, various other recreation goods (such as musical instruments, toys, sporting goods, pet and garden products, etc.), and recreation and cultural services. For several countries, we are

[6]Classifying all time spent with children, such as playing games and going to a zoo, as childcare "work" rather than "leisure" moderates this trend somewhat — see discussion in Ramey and Francis (2009) and Aguiar and Hurst (2007a).

[7]Using decennial data from the Census, McGrattan et al. (2004) also find that hours per worker have declined and hours per capita have increased in the U.S. since 1950. Kendrick et al. (1961) and Whaples (1991) document a decline in work hours since 1830 (see also Figure 1 in Vandenbroucke, 2009). Kendrick et al. (1961) also show that this decline has happened in all industries.

[8]We use the price of all consumption goods and services as deflator for all nominal variables.

[9]These categories follow the BLS classification. The BLS price data in not available before 1967. We rely on Owen (1971) and data from the Bureau of the Census (1975) for the earlier years. See Appendix A for more details.



(a) Men

(b) Women

Annual hours spent on market work, total work and leisure. Market work includes any work-related activities, travel related to work, and job search activities. Total work includes market work, home production, shopping, and non-recreational childcare. Leisure is any time not allocated to market and nonmarket work, net of time required for fulfilling biological necessities (8 hours per day). Sample includes people between 16 and 64 years old who are not full-time students. Source: ATUS, Aguiar and Hurst (2007b) and Aguiar et al. (2017).

Figure 2: Market work, total work, and leisure in the U.S.

able to augment these data using price series from national statistical agencies. We restrict the sample to countries with at least 15 years of data for recreation prices. Our final sample covers 42 countries and 1,215 country-year observations.[10]

Figure 3 shows the evolution of hours worked (both per capita and per worker), recreation prices and wages for a selected group of countries in our sample.[11] The black curves represent the global movements in these quantities. They show the years fixed effects from a regression that also includes country fixed effects to account for country heterogeneity. While there is some heterogeneity across countries, the figure shows a clear overall decline in both hours and recreation prices, and an increase in real wages. Across the full sample, we find that per capita hours have been declining at an average rate of 0.46% per year and hours per worker have been declining at 0.62% per year.[12] At the same time, real wages have been increasing by 2.00% per year, and real recreation prices have been declining by 1.09% per year.[13]

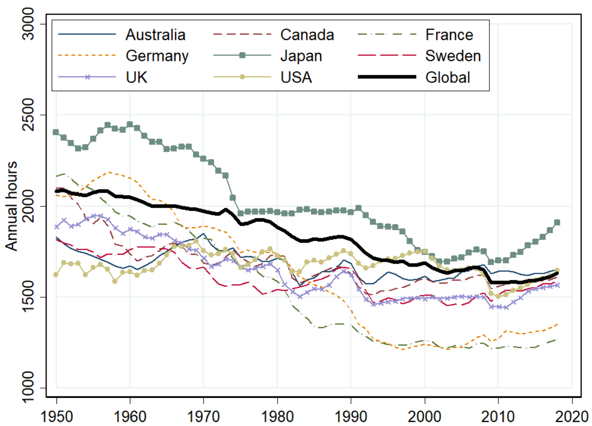
To show how widespread these patterns are, Table 7 in Appendix provides the list of countries in

[10]Data on hours worked comes from the Total Economy Database of the Conference Board. We compute hours per capita by dividing total hours worked by the working age population (25-64 years old), and similarly for hours per worker. Population and labor force statistics by age and sex are from the OECD. We use the OECD and Eurostat compensation of employees divided by hours as our main measure of wages. We adjust all prices for inflation using the country-specific all-item consumer price index. More information about how the dataset is constructed is provided in Appendix A.

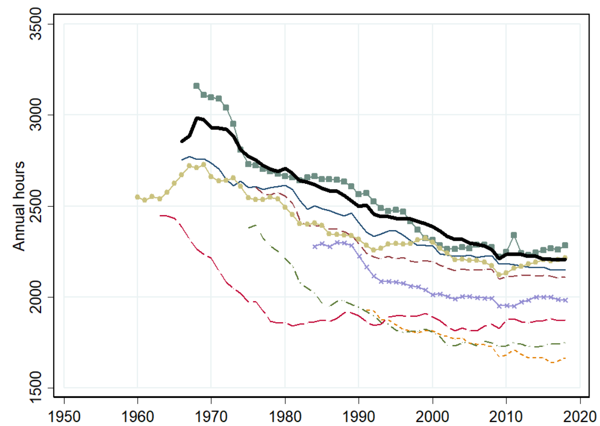
[11]See Figure 8 in Appendix B.1 for the same graphs with all the countries in our sample.

[12]Table 1 in Huberman and Minns (2007) shows that the decline in hours per worker goes back to at least 1870 in Australia, Canada, the United States and Western Europe.

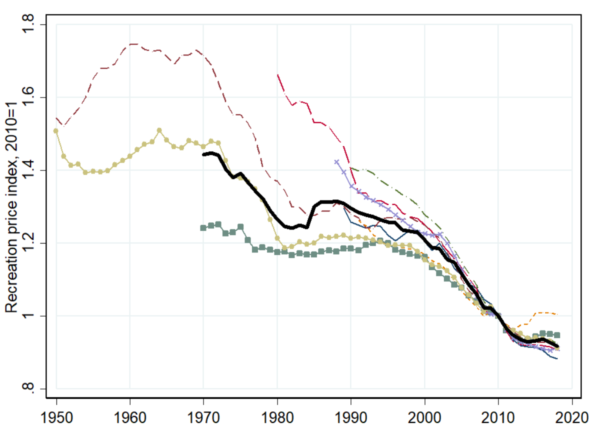
[13]We compute these growth rates by running a pooled regression of a given variable of interest x_{lt} in country l at time t on the time trend and a set of country fixed effects α_l, so that $\log x_{lt} = \alpha_l + \gamma^x t + \varepsilon_{lt}$. The coefficient γ^x therefore provides a measure of average growth rates for variable x across countries.



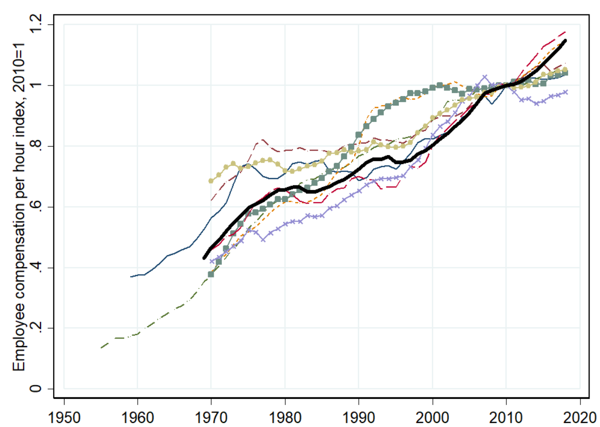
(a) Hours per capita



(b) Hours per worker



(c) Real recreation prices



(d) Real wages

The bold black lines show the year fixed effects from regressions of the corresponding variable on a set of country and year fixed effects, with all countries included. Regressions are weighted by country-specific total hours. For panels (a) and (b), the levels of the lines are normalized to all-country weighted averages in 2015. Panel (a): Annual hours worked over population between 25 and 64 years old. Source: Total Economy Database and OECD. Panel (b): Annual hours worked over number of employed between 25 and 64 years old. Source: Total Economy Database and OECD. Panel (c): Price of consumption for OECD category "Recreation and culture", normalized by price index for all consumption items. Base year = 2010. Source: OECD, Eurostat, national statistical agencies. Panel (d): Real compensation of employees divided by hours worked. Base year = 2010. Source: OECD, Eurostat and Total Economy Database.

Figure 3: Hours, wages and recreation prices for a selected group of countries.

our sample along with their individual average growth rates for hours, wages and recreation prices. We observe, first, that there has been a broad decline in hours worked throughout our sample. Hours per capita have had a negative growth rate in 34 countries out of 42. The decline is even more pronounced when looking at hours per worker, which have declined in all but two countries (Lithuania and Luxembourg). Second, the growth in real wages is positive for all countries except Mexico, which experienced a large decline in real wages in the 1980's due to very high inflation rates.

Real recreation prices have also been declining worldwide. As the table shows, we find a negative growth rate for *all* countries in our sample, and these growth rates are statistically different from zero at the 1% level in all cases. The coefficients are also economically large. Even for the country with the slowest decline (Ireland), recreation prices have still gone down by 0.4% per year, a large number when compounded over a hundred years. Compared to the other countries in our sample, the United States experienced a relatively slow decline in real recreation prices (−0.7% per year). Only four countries (Ireland, Japan, Luxembourg and Norway) went through slower declines.

2.2 Cross-country regressions

To better highlight the relationship between hours worked and recreation prices, we provide a series of cross-country regressions. For each country i in our sample, we focus on a time period for which data on wages, hours and prices are available simultaneously and then compute the average annual growth rate in hours per capita $\Delta \log h_i$, wages $\Delta \log w_i$ and recreation prices $\Delta \log p_i$.[14] We then estimate cross-sectional specifications of the form

$$\Delta \log h_i = \beta_0 + \beta_p \Delta \log p_i + \beta_w \Delta \log w_i + \gamma X_i + \varepsilon_i, \tag{1}$$

where X_i includes some additional controls, ε_i is an error term and β_0 is a constant to absorb any aggregate changes.

The results are presented in Table 1. In the first column, we use real GDP per hour as a proxy for wages. That data is widely available and allows us to compute growth rates over longer time periods. In column (2) and (3), we use real employee compensation per hour and real GDP per capita instead. In all cases, we see a positive association between the growth rates of hours per capita and recreation prices, which is consistent with individuals reducing their work hours to enjoy more leisure in the face of cheaper recreations goods and services. In the fourth column, we control

[14] We construct hours per capita by dividing total hours worked by the population between 25 and 64 years old. In Appendix B.2, we show that dividing by the population between 20 and 74 instead has only a limited impact on the results. We construct the growth rates $\Delta \log x_i$ by averaging, for each country i, the quantity $\log (x_{it+1}/x_{it})$ over the available years. We remove the Great Recession years (2008 and 2009) from the sample as they are clear outliers that can substantially change the estimate of steady-state growth rates given the small number of years available for some countries. In Appendix B.2, we show that keeping these years in the sample increase the statistical significance of most estimates.

for (the average annual growth of) female labor force participation which, as noted earlier, has been been an important driver of movements in hours per capita over the last century. In column (5), we also control for (the average annual growth of) the share of young men in the population to account for potential changes in behavior documented by Aguiar et al. (2017). In both cases, recreation prices remain significantly and positively associated with hours per capita. In contrast, in all but one specification we detect small point estimates and no significant association between wages and hours per capita, which would be consistent with the substitution and income effects roughly offsetting each other.[15]

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Growth in hours per capita $\Delta \log h$				
$\Delta \log p$	0.290**	0.291**	0.266**	0.291**	0.281**
	(0.109)	(0.110)	(0.106)	(0.110)	(0.110)
$\Delta \log w$					
GDP per hour	0.035			0.043	0.027
	(0.073)			(0.072)	(0.079)
Empl. comp. per hour		0.020			
		(0.065)			
GDP per capita			0.123**		
			(0.046)		
Female labor force part.				0.068	
				(0.125)	
Share of young male in pop.					0.062
					(0.148)
R^2	0.124	0.118	0.256	0.134	0.129
Observations	42	42	42	42	42

Robust standard errors are in parentheses. $^{*}, ^{**}, ^{***}$ indicate significance at the 10%, 5%, and 1% levels, respectively. All variables are in growth rates. Growth rates are annual averages over all years except for 2008 and 2009. Population includes individuals between 25 and 64 years old.

Table 1: Cross-country regressions of hours per capita on recreation prices and wages.

2.3 Exploiting household-level variation

The regressions of Table 1 show an association between recreation prices and work hours but they are silent about any causal link between the two. One worry is that some shock or mechanism could create a correlation between the regressors and the error term in (1), due to the endogeneity

[15]Table 8 in the appendix shows the outcome of the same regressions but with growth in hours per worker as dependent variable. The point estimates for the impact of recreation prices are a bit smaller and not statistically significant, which might indicate that recreation affects labor supply along both the intensive and extensive margins. We will come back to the effect of recreation prices on hours per worker in Section 4 when we estimate the structural model.

of our right-hand side variables. For instance, a shock to preferences that makes leisure more enjoyable would reduce labor supply and increase the demand for recreation items. As a result, wages and recreation prices would go up and so this shock would tend to push for more negative β_w and β_p, and invalidate the causal interpretation of the coefficients.

In this section, we rely on household-level data from the United States to construct two instruments, one for wages and one for recreation prices, in order to address these potential endogeneity issues. Our wage instrument relies on the differences sector-level employment across U.S. localities and across demographic groups, as is relatively standard in the literature (Bartik, 1991). In the same spirit, we construct a novel instrument for recreation prices that takes advantage of differences in recreation consumption bundles across households with different demographic characteristics.

Data

To construct the needed measures of hours and earnings at the locality-demographic-industry level, we use data from the U.S. Census (years 1980 and 1990) and the Census' American Community Surveys (2014-2018 five-year sample). We denote the years 1980 and 1990 as $t = 0$ and $t = 1$, respectively, while the 2014-2018 period is $t = 2$. Later on, we will use the data from $t = 0$ (the "pre-period") to construct the instruments, while the data from $t = 1$ and $t = 2$ will be used to compute the growth rates of the variables of interest. One key advantage of the Census data is that they cover a large sample of the U.S. population, which allows us to exploit variation across 741 commuting zones, defined as in Dorn et al. (2019). We limit our analysis to individuals between the ages of 25 and 64, and split them into 15 demographic groups based on age and education.[16] Overall, such demographic-locality split implies 11,115 groups. We exclude groups with less than 50 individual observations, leaving us with 10,469 groups.

Our data on recreation and nonrecreation consumption come from the interview part of the Consumption Expenditure Survey (CE). We follow Aguiar and Bils (2015) in constructing and cleaning the sample.[17] We split all recreation consumption expenditures into the seven subcategories used by the BLS to build price indices for these subcategories: Audio-video, Sports, Pets, Photo, Reading, Other goods (including toys and musical instruments), Other services (including admissions, fees for lessons and instructions, club memberships, etc.).[18]

[16] The age groups are "25-34 years old", "35-49 years old", "50-64 years old". The education groups are "less than high school", "high school", "some college", "four years of college" and "more than college". We exclude individuals serving in the armed forces and institutional inmates.

[17] We use the CE data between 1980 and 1988 as the $t = 0$ period, and the 1989-1991 and 2014-2018 periods serve as $t = 1$ and $t = 2$, respectively. We pool observations between 1980 and 1988 to reduce noise, since the CE has on average only 1484 annual observations. The results are largely unchanged if we use a shorter pooling period instead.

[18] When constructing recreation consumption baskets across demographic groups, we use the demographic characteristics of the reference person. By definition, "the reference person of the consumer unit is the first member mentioned by the respondent when asked 'What are the names of all the persons living or staying here? Start with the name of the person or one of the persons who owns or rents the home'. It is with respect to this person that the relationship of the other consumer unit members is determined". Our measures of wages and hours from the Census

Specification

We estimate how the growth in hours per capita h is affected by the growth in real recreation prices p and wages w. Namely, our main specification is

$$\Delta \log h_{gl} = \beta_0 + \beta_p \Delta \log p_g + \beta_w \Delta \log w_{gl} + \gamma X_{gl} + \varepsilon_{gl}, \tag{2}$$

where the subscripts g and l denote, respectively, demographic groups and localities. The operator Δ computes differences between $t = 1$ and $t = 2$ outcomes. We also allow for a set of control variables X_{gl} that we specify later. All variables are demographic- and location-specific except for recreation prices which are not available at the local level. We instead construct demographic-specific prices by using the demographic-specific consumption shares of various types of recreation items together with the aggregate prices of these items.[19] Note that (2) is a purely cross-sectional regression with no time dimension. The identification comes from variations across localities and demographic groups, and aggregate trends are absorbed by the constant in the estimation.

We now turn to the description of the instruments that we use to estimate (2), beginning with our instrument for recreation prices.

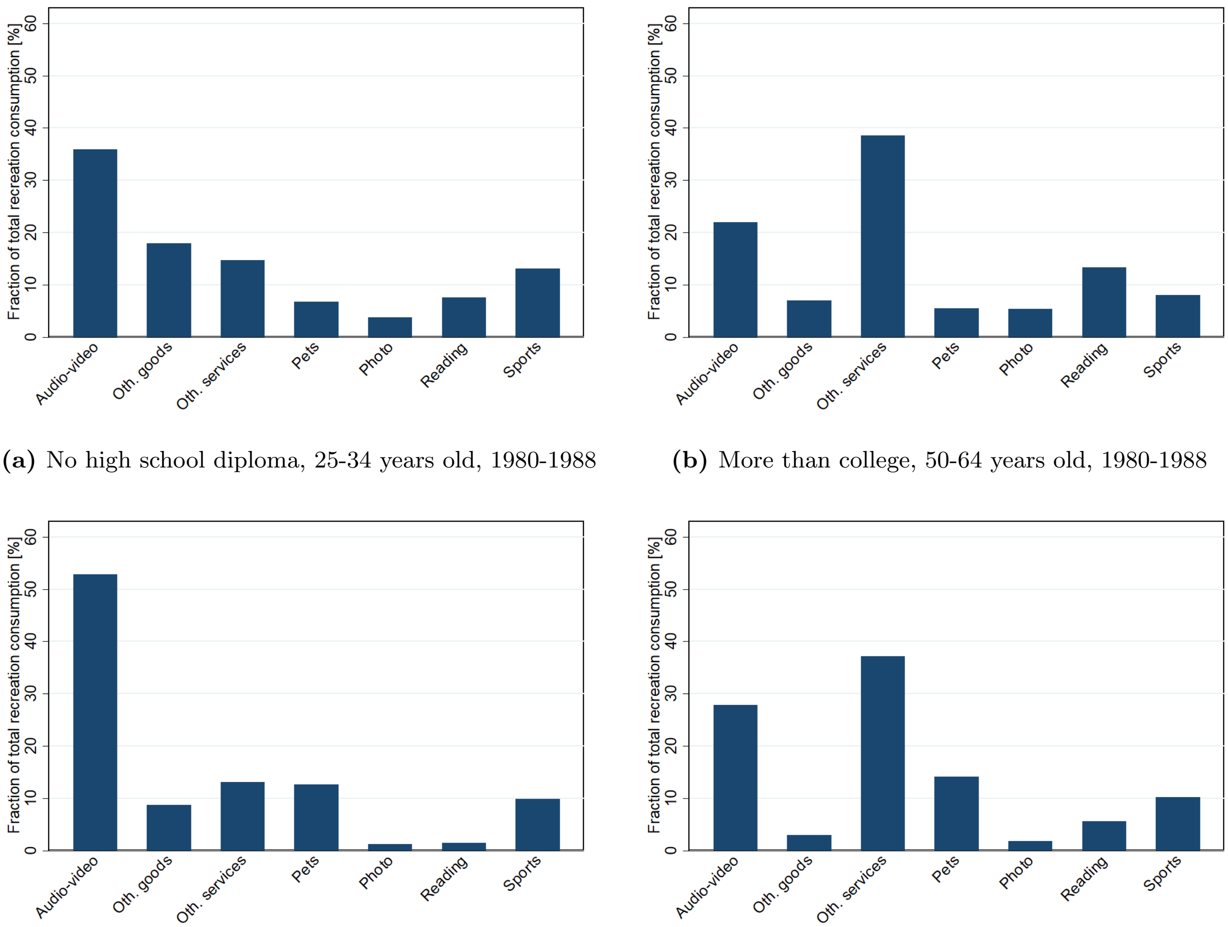
2.3.0.1 Instrument for recreation prices In the United States, there are large differences in the type of recreation items that are consumed by households with different demographic characteristics, such as education and age. For instance, panel (a) of Figure 4 shows how households whose heads are between 25 and 34 years old and do not have a high school diploma allocated their recreation spending in the period between 1980 and 1988. Panel (b) provides the same information for households whose heads have more than a college degree and who are between 50 and 64. We see that the consumption baskets vary substantially across these demographics. In particular, young and less-educated households spend disproportionally more on "Audio-video" items, while older and more educated households spend more on "Other services".[20] Panels (c) and (d), which provides the same shares over the 2010-2018 period, show that these differences remain in the most recent decade and, if anything, have become starker.

While Figure 4 shows that different households consume different recreation items, the price of these items have also evolved very differently over the last three decades. As we can see from Figure 5, the real price of "Audio-video" items, disproportionately consumed by young less-educated households, has declined by 60% since 1980. In contrast, the average price of items in the "Other

are at the individual level. Our results are similar if we instead only use hours and wage data for the household heads only (see Appendix B.4.4).

[19] Since only relative prices matter, we start from an arbitrary point and construct the series $p_{g,t}$ according to the formula $\frac{p_{g,t+1}}{p_{g,t}} = \sum_j \frac{c_{jg,t+1}}{\sum_i c_{ig,t+1}} \frac{p^{US}_{j,t+1}}{p^{US}_{j,t}}$ where c_{jgt} is the consumption by group g of recreation item j at time t.

[20] Figure 10 in Appendix B.4.2 shows that education alone can account for large variations in spending habits on recreation items.



(a) No high school diploma, 25-34 years old, 1980-1988

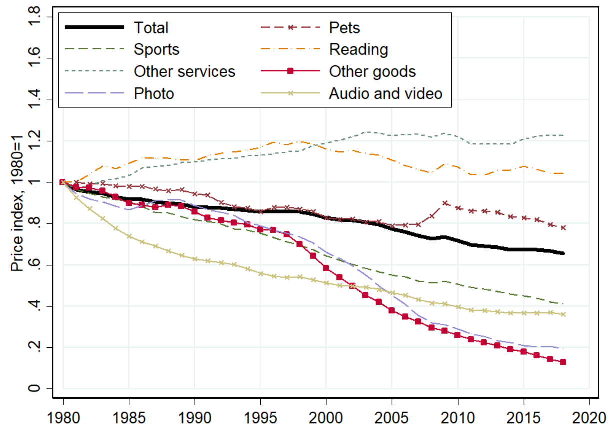
(b) More than college, 50-64 years old, 1980-1988

(c) No high school diploma, 25-34 years old, 2010-2018

(d) More than college, 50-64 years old, 2010-2018

Shares of different items in total recreation consumption, constructed by pooling observations for the two periods, 1980-1988 and 2010-2018. Source: Consumer Expenditure Survey.

Figure 4: Share of recreation spending across education and age groups.



Real U.S.-wide price of various recreation goods and services. Source: BLS.

Figure 5: Real prices of different recreation goods and services.

services" categories, mostly consumed by old highly-educated households, has increased by about 20%. As a result, the price of the recreation basket has evolved very differently across demographic groups.

We use this variation to construct the shift-share instrument

$$\Delta \log p_g^{IV} = \sum_j \frac{c_{jg}^0}{\sum_i c_{ig}^0} \Delta \log p_j^{US}, \tag{3}$$

where $\Delta \log p_j^{US}$ denotes the change in the nation-wide price of recreation items of type j between the periods $t = 1$ and $t = 2$. The quantity c_{jg}^0 denotes the nominal consumption expenditure of recreation items of type j by individuals in demographic group g in period $t = 0$. As 3 shows, the instrument captures how nation-wide changes in prices $\Delta \log p_j^{US}$ affect the price of the recreation bundle for a household of given demographic characteristics.[21]

For this instrument to be relevant, it must be that growth in the demographic-specific recreation prices $\Delta \log p_g$ in (2) is correlated with the *initial* composition of the basket of recreation consumption, as captured by the shares $c_{jg}^0 / \sum_i c_{ig}^0$ in 3. Figure 4 suggests that this is indeed the case. As the figure shows, these shares are quite persistent over time and, as a result the initial basket should be a good predictor of the growth in the price of the basket going forward. Since there are large differences in the growth of the price of different recreation items (5), the instrument (3) should vary substantially across demographic groups and be strong. Below, we confirm this

[21] A similar approach is used by Acemoglu and Linn (2004) to instrument for changes in demand for new drugs, as they interact expenditure shares of individual goods with demographic changes in order to capture shifts in market sizes over time. As shown by Goldsmith-Pinkham et al. (2018) in the context of the standard Bartik instrument, this construction is essentially equivalent to a differences-in-differences research design. We discuss the robustness of that instrument below. See also discussion in Goldsmith-Pinkham et al. (2018) of the implicit assumptions under which the exclusion restriction is satisfied, in particular the absence of geographical spillovers due to worker mobility, etc.

formally by showing that the first-stage F-statistics are large.

For that instrument to be valid, it must be that the consumption shares $c^0_{jg}/\sum_i c^0_{ig}$ are exogenous, i.e. uncorrelated with the error term in the reduced-form equation (2) (Goldsmith-Pinkham et al., 2018). We view that assumption as reasonable for several reasons. First, we make sure to compute the shares in the pre-period ($t = 0$) to minimize their correlation with any potential omitted variables at $t = 1$ and $t = 2$, the period over which the growth rates are computed. Second, we view the consumption shares as being largely driven by differences in preferences (which, in particular, explains their persistence over time, as shown in Figure 4). For instance, college might introduce students to the theater, leading some of them to consume theater plays after graduation. These deep-seated preferences are unlikely to be related to random shocks that would also affect the error term ε_{gl} in (2). Of course, other economic outcomes such as the price of different recreation items and household income might also affect the shares, but in that case the shares would be mainly affected by the *level* of these variables in $t = 0$ and not by the *change* in these variables between $t = 1$ and $t = 2$, which are the quantities that would be most likely to be correlated with ε_{gl}.

Pre-trends

To further check the validity of our instrument, we can look at pre-trends in work hours since the 1960s and explore how they relate to household recreation bundles. We do so in Figure 6 where we show in panel (a) the separate evolution of the real price of recreation commodities, mostly consumed by younger low-educated individuals, and services, mostly consumed by older and highly educated individuals, between 1967 and 1998.[22] Interestingly, we see that the time series follow each other closely until about 1980 and then diverge markedly afterward. From 1982 on, the real price of recreation commodities has been on a steady decline while the real price of recreation services has been increasing. Panel (b) shows the evolution in the work hours of households with a high-school diploma or less and at least a college degree. Between 1965 and 1985 the hours of these two groups has gone down by almost exactly the same amount. After 1985, however, high-school households have seen their work hours go down relative to their college-educated counterparts. Panel (c) shows similar patterns for total leisure time.

Figure 6 is reassuring for the exogeneity of our instrument. That both college and high-school work hours have declined by the same amount between 1965 and 1980, when the price of their recreation bundles moved together, points against some unobserved covariate that would differentially affect households with different demographics and that might be correlated with the consumption shares.

[22]These series were discontinued in 1998 due to changes in the classification scheme. But importantly, and as evident from Figure 5, the diverging trends of real prices of recreation commodities and services are also present during the two latest decades.

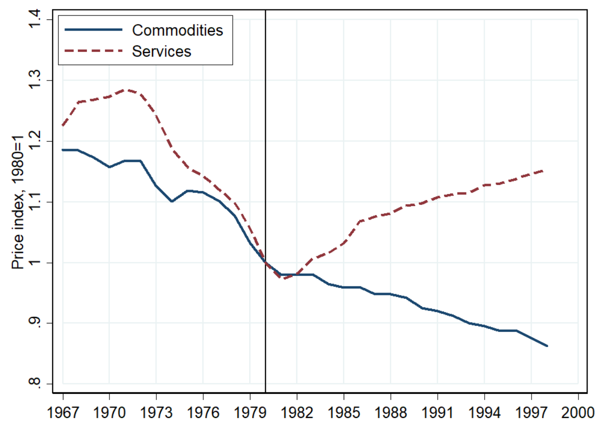
The patterns in Figure 6 can also provide an explanation for the recent rise in leisure inequality that has been discussed by, among others, Aguiar and Hurst (2009) and Attanasio et al. (2014). As we can see from panel (c), leisure time has grown the most among the less-educated. These individuals have also faced the slowest growth in wages over that period so that the income effect alone would be unable to explain their relative rise in leisure time (in fact, it might suggest that the substitution effect rather than the income effect dominates). At the same time, the price of recreation items that these households tend to consume has declined significantly, making leisure effectively more attractive for them. In contrast, the real relative price of recreation items consumed by more-educated households has been increasing, but so have their wages. As a result, the two effects roughly offset each other, explaining why their leisure time has been more stable over the last decades.

Addressing potential threats to identification

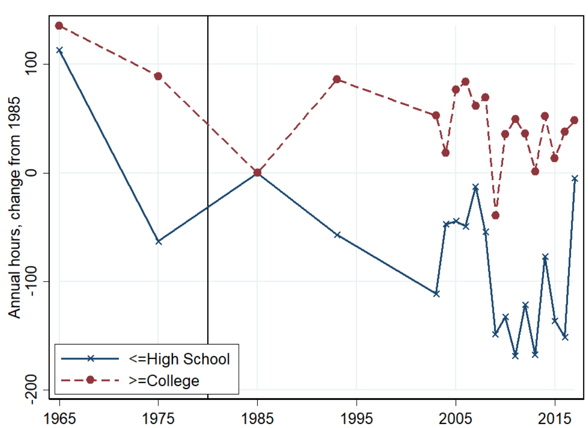
While the evidence from Figure 6 is reassuring, we can think of other shocks that could potentially threaten the exogeneity of the instrument. One prominent example is off-shoring: Over the past decades, manufacturing jobs have been moving overseas at the same time as technological improvements have led to cheaper recreation goods. These changes might have affected different demographic groups in different ways thereby creating a correlation with the consumption shares (e.g., Autor et al., 2006, Autor and Dorn, 2013, Bloom et al., 2019, Jaimovich and Siu, 2020). In particular, less-educated workers in the manufacturing sector have been disproportionately affected. While we believe that the presence of wages in equation (2) largely takes care of any potential endogeneity, in some specifications we also control for the share of each demographic-locality group employed in manufacturing in 1980, well before the relevant movements in technology occurred, to make sure that these trends are not driving our results.

In addition, it is possible that certain changes in demographic attributes between $t = 1$ and $t = 2$ might affect both hours worked and, at the same time, be correlated with the consumption shares. For instance, the rise in disability benefits over the last decades might have had a negative impact on hours worked, be correlated with the consumption shares of low-education people, and not be controlled for by the other covariates on the right-hand side of (2)(e.g., see Abraham and Kearney, 2020 for an overview). For that reason, we also include a set of additional demographic controls in some specifications. These controls are, for each location-demographic group, the fractions of males, whites, married and people with disabilities (see Appendix A for a detailed description of the variables). We control for the 1980 values of these fractions, as well as for their growth rates between 1990 and 2016.[23]

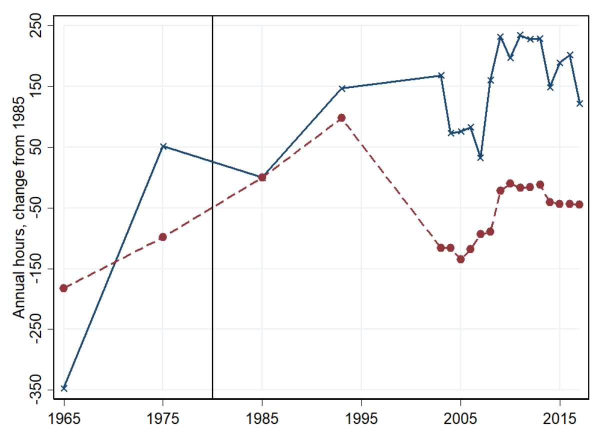
[23] Recall that to construct recreation prices for different demographic groups we use the household-level CE data, while our measures of wages and hours from the Census are at the individual level. In Appendix B.4.4, we redo the same regressions using hours and wage data for all household heads and married household heads, with additional controls for the number of kids, and find very similar results.



(a) Real prices of recreation commodities and services, 1967-1998



(b) Market work hours by education, 1965-2017



(c) Leisure hours by education, 1965-2017

The vertical black lines denote the start of the detailed consumption and price data. Panel (a): Real U.S.-wide price of recreation commodities and services. Source: BLS. Panels (b) and (c): Evolution of work and leisure annual hours for individuals with no more than high school diploma and at least four years of college. Market work includes any work-related activities, travel related to work, and job search activities. Leisure is any time not allocated to market and nonmarket work (home production, shopping, non-recreational childcare), net of time required for fulfilling biological necessities (8 hours per day). Sample includes people between 16 and 64 years old who are not full-time students. Source: ATUS, Aguiar and Hurst (2007b) and Aguiar et al. (2017).

Figure 6: Pre-trends in work hours, leisure hours, and recreation prices

2.3.0.2 Instrument for wages In addition to our instrument for recreation prices, we also construct a second instrument, this time for wages. Here, we follow the standard approach of Bartik (1991). We use initial variation in industrial employment across localities and demographic group together with nation-wide changes in wages by industry to construct a measure of changes in wages that are driven by factors independent of regional labor market conditions, such as technological growth, etc. [24] To be precise, we compute

$$\Delta \log w_{gl}^{IV} = \sum_i \frac{e_{igl}^0}{\sum_j e_{jgl}^0} \Delta \log e_{ig}^{US} - \sum_i \frac{h_{igl}^0}{\sum_j h_{jgl}^0} \Delta \log h_{ig}^{US}, \tag{4}$$

where i denotes an industry, g is a demographic group, and l is a locality.[25] As before, the operator Δ denotes the total growth rate between $t = 1$ and $t = 2$. The variable $e_{igl} = w_{igl} \times h_{igl}$ refers to labor earnings and h_{igl} is total hours worked. As (4) shows, we construct $\Delta \log w_{gl}^{IV}$ by first computing the fraction of earnings and hours worked that can be attributed to an industry i in a given locality-demographic unit (g, l) in the pre-period $t = 0$. Since these shares provide a measure of how sensitive local earnings and hours are to aggregate changes in industry i, we can then compute $\Delta \log w_{gl}^{IV}$ as the growth rate in local wages that can be attributed to changes in the national factors $\Delta \log e_{ig}^{US}$ and $\Delta \log h_{ig}^{US}$.

2.3.0.3 Estimation results The outcome of the estimation is presented in Table 2, where the first three columns refer to ordinary-least square regressions and the last three columns take advantage of our two instruments. In all cases, the F-statistics are large, suggesting that the instruments are strong. In columns (2)-(3) and (5)-(6) we allow for additional demographic controls.[26] Columns (3) and (6) also control for the share of manufacturing hours in each demographic group in 1980.[27]

In all specifications, an increase in recreation prices is associated with an increase in work hours. The coefficients are strongly statistically and economically significant with a decline in real recreation prices of 1 percent associated with a 0.47 percent decline in hours worked in our preferred specification (column 6). Importantly, this effect is even stronger in the IV regressions, which are less subject to the endogeneity issues. We also find a significant effect of wages on hours worked. In all the specifications that we consider, the income effect dominates, so that an increase in wages is

[24] Our industry classification includes 34 industries. See Appendix A.1.1 for details.

[25] We show in Appendix B.4.1 that equation (4) can be derived from the definition of labor earnings $e_{iglt} = w_{iglt} \times h_{iglt}$ together with replacing local growth rates $\frac{x_{iglt+1}}{x_{iglt}}$, for some variable x, by their nation-wide equivalent $\left(\frac{x_{igt+1}}{x_{igt}}\right)^{US}$.

[26] Changes in some of demographic variables between $t = 1$ and $t = 2$ (such as fractions of married individuals and people with disabilities) might be affected by the treatment themselves and so might be "bad controls". To address this issue, we also run the same regressions by only including the 1980 values of demographic controls. The results are largely unchanged.

[27] Standard errors are clustered at the locality level. The results for recreation prices and wages stay significant at the 5% level if we cluster standard errors at both the locality and demographic group levels. We prefer not to perform double clustering in our main analysis because we have only 15 demographic groups.

	(1): OLS	(2): OLS	(3): OLS	(4): IV	(5): IV	(6): IV
	Dependent variable: Growth in hours per capita $\Delta \log h$					
$\Delta \log p$	0.427^{***}	0.474^{***}	0.204^{***}	0.763^{***}	0.761^{***}	0.466^{***}
	(0.025)	(0.036)	(0.041)	(0.047)	(0.062)	(0.066)
$\Delta \log w$	-0.048^{***}	-0.093^{***}	-0.094^{***}	-0.713^{***}	-0.539^{***}	-0.529^{***}
	(0.015)	(0.013)	(0.013)	(0.074)	(0.070)	(0.068)
1980 manuf. hours			-0.285^{***}			-0.286^{***}
			(0.023)			(0.025)
Locality F.E.	Y	Y	Y	Y	Y	Y
Addtl. dem. cont.	N	Y	Y	N	Y	Y
F-statistics	—	—	—	145.1	124.7	124.8
R^2	0.304	0.452	0.469	—	—	—
Observations	10,469	10,469	10,469	10,469	10,469	10,469

Standard errors clustered at the locality level in parentheses. *,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively. F-statistics are Kleibergen-Paap. The regressions are across people sorted by locality/education-age group. Columns marked by "IV" use Bartik-like instruments for wages and recreation prices. Controls include manufacturing hours share in 1980 and a rich set of additional demographic controls (see text for details).

Table 2: Regressions of hours per capita on recreation prices and wages across locality/demographic-sorted households.

associated with a decline in work hours. The magnitude of this effect, however, changes markedly across specifications. In the OLS regressions (columns 1 to 3), the impact of wages is quite weak while the IV estimation finds a stronger effect. This is consistent with the fact that both measured recreation prices and wages are endogenous. For instance, a technological improvement in leisure goods drives down the effective price of a unit of leisure, but by incentivizing workers to supply less labor in order to enjoy more leisure time it puts upward pressure on observed wages. This might mute the initial reduction in hours, thus pushing the coefficient on wages towards zero. Using the shift-share instrument allows us to isolate the impact of exogenous changes in wages on labor supply that is not contaminated by such equilibrium effects. Indeed, it is crucial to include both the (instrumented) recreation prices and wages in the same regression in order to disentangle these effects, as including wages only produces either a small/insignificant or even a positive coefficient (suggesting that the substitution effect dominates), as we show in Appendix B.4.3.

Additional demographic controls have only a limited impact on the coefficients in Table 2, but increase the explanatory power significantly, suggesting that their impact on work hours might be orthogonal to that of wages and recreations prices. Adding 1980 manufacturing employment shares as a control somewhat lowers the recreation price coefficient while leaving the wage coefficient unaffected.

3 Model

In the previous section, we presented reduced-form evidence for a relationship between recreation prices and work hours. But that evidence alone does not inform us about the origin of that relationship and about which features of the economy influence its strength. For instance, it is unclear whether that relationship is structural or if it could change in response to policy interventions. In order to gain a better understanding of the mechanisms involved we build a macroeconomic model of labor supply in which wages and recreation prices affect work hours. Our goal is to build a model that is general, microfounded, and can easily be brought to the data. We then estimate the model in the next section and use it as a tool to disentangle how the different economic forces affect hours worked.

3.1 Balanced-growth-path facts

Since our goal is to explain economic changes that occur over long time horizons, we adopt the standard macroeconomic framework for this type of analysis, namely that of a balanced-growth path. In what follows, we therefore assume that prices and quantities grow at constant, but perhaps different, growth rates. That framework offers a good description of the evolution of the U.S. economy over the long-run, so that we can be sure that our model economy does not clash with important regularities in the data. We however make one important departure from the usual balanced growth assumptions: we do not impose that hours worked remain constant over time. Instead, we allow them to also decline at a constant rate.

In a recent paper, Boppart and Krusell (2020) show that — apart from hours dynamics — stylized balanced-growth facts, as outlined by Kaldor (1961), remain valid for the United States today. However, these facts do not distinguish between different types of consumption. Our modeling strategy, described below, assumes that the consumption of recreation and non-recreation items evolve in such a way that their ratio remains constant over time. Before going through the details of the model, we therefore provide some evidence to show that this assumption is justified for the United States and our sample of countries.

For the United States, we use consumption data from the NIPA tables and construct a measure of recreation consumption that includes items such as video and audio equipment, sports goods, memberships and admissions, gambling, recreational reading materials, pet products, photographic goods and services, and package tours (see Appendix A for the details of that exercise). We then compute the share of recreation in total consumption expenditure and plot that measure as the blue solid line in panel (a) of Figure 7. As we can see, this share has remained roughly constant over the last hundred years, moving from about six percent in 1929 to seven percent today.[28]

[28] Our finding that the share of recreation consumption has been roughly constant is in contrast with earlier work by Kopecky (2011) who uses data from Lebergott (2014) and finds an increasing recreation share over the twentieth

When constructing our measure of recreation consumption, we follow the classification used by the BLS and exclude information processing equipment (i.e. computers), which might also be used for work or education. We however provide an alternative measure, displayed in red in panel (a) that includes all of these expenditures in the recreation category. In this case, the share of recreation expenditure increases slightly over our sample.[29] To further emphasize that the share of recreation consumption has remained constant, we also construct expenditures on recreation goods and services using the CE data. That measure is also shown, in green, in panel (a). Although it is only available since 1980, it has remained fairly stable since then.

Since our analysis is not limited to the U.S. economy, we also compute the recreation consumption shares for other countries in our sample, using data from the OECD and Eurostat. Our measure of recreation consumption corresponds to the 'Recreation and culture' category and includes the same goods and services as the recreation price data that was discussed in Section 2.1.[30] Panel (b) shows that measure for a selected group of countries, and we include the same figure for all countries in Appendix B.1. While there is some variation across countries, the recreation shares stay fairly constant over time, in line with our modeling assumption.

3.2 Problem of the household

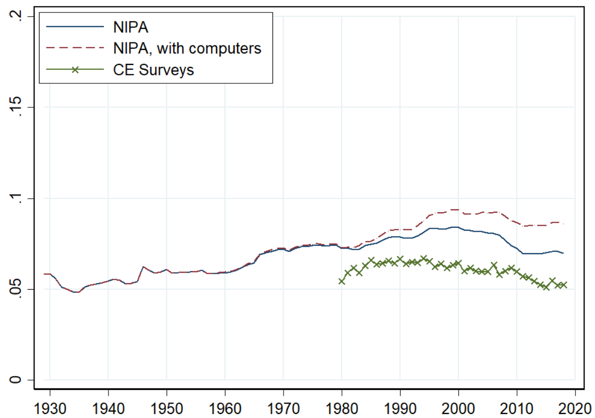
We now turn to the description of our model economy. At the heart of our analysis is a household — representative or else — that maximizes some period utility function u. Our main mechanism operates through the impact of cheaper recreation goods and services on labor supply decisions. We therefore include these items, denoted by d, directly into u. The utility function also depends on the consumption of other goods and services c, and on the amount of time worked h. Since it plays a central role, we keep the utility function as general as possible, only assuming that it be consistent with a balanced-growth path — the benchmark macroeconomic framework for long-run analysis. We will show below that this assumption imposes some structure on the shape of the utility function.

Importantly for our mechanism, the utility function is free to feature some complementarity between leisure time and recreation consumption, such that, for instance, the purchase of a subscription to an online streaming service can make leisure time more enjoyable, which then pushes

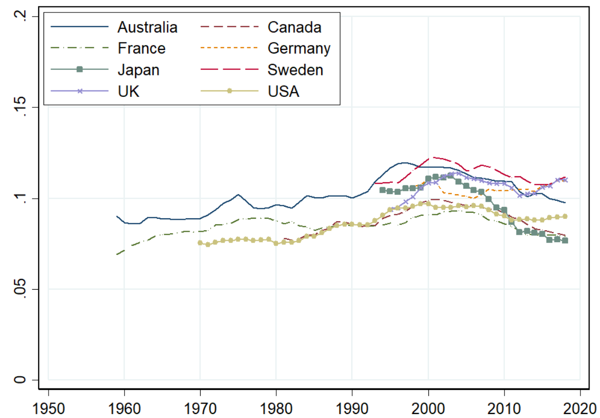
century. Two important differences between the datasets are responsible for the different conclusions. First, our sample includes additional data from 2000 to 2019, a period over which the recreation share has declined by more than one percentage point. Second, Lebergott (2014) finds a large increase (from three to six percentage points) in the recreation share between 1900 and 1929 (see Figure 3 in Kopecky, 2011). But, unlike the rest of the time series, these data are not from NIPA, but are instead imputed from a variety of sources. For instance, adjusted sectoral wages are used as a proxy for the consumption of recreation services. While we cannot rule out a small increase in the recreation share since 1900, we view the data since 1930 as more reliable for estimating its overall trend.

[29] Kopecky (2011) argues that up to 30% of transportation expenses are related to social and recreational trips. The transportation expenditure share has been slowly declining starting from 1980. Including transportation expenditures in the recreation consumption category would largely undo the impact of computers.

[30] Since the consumption categories are not as fine as the ones available from the NIPA tables, we cannot exclude information processing equipment and computers are therefore counted as recreation in this measure.



(a) Recreation consumption share: United States



(b) Recreation consumption share: International sample

Panel (a): Fraction of recreation consumption in total consumption for the United States. Source: NIPA and CE Surveys. Panel (b): Fraction of recreation consumption in total consumption for a selected group of countries. Source: OECD and Eurostat.

Figure 7: Income, consumption and recreation consumption.

the household to work less. It follows that with such a complementarity a decline in recreation prices can lead to a decline in work hours.

The household maximizes its lifetime discounted utility

$$\sum_{t=0}^{\infty} \beta^t u\left(c_t, h_t, d_t\right), \tag{5}$$

subject to a budget constraint

$$c_t + p_{dt} d_t + a_{t+1} = w_t h_t + a_t\left(1 + r_t\right), \tag{6}$$

where w_t denotes the wage, p_{dt} the price of recreation goods, r_t the interest rate, and a_{t+1} the asset position of the household at the end of period t.[31] Since time worked h_t is constrained by the size of the (normalized) time endowment, we assume $h_t \leq 1$, but we focus on interior solutions so this inequality never binds.

The household chooses $\{c_t, d_t, h_t, a_{t+1}\}$ while taking the prices $\{w_t, p_{dt}, r_t\}$ as given. On a balanced-growth path the prices $\{w_t, p_{dt}\}$ grow at constant rates, and the interest rate $r_t > 0$ remains constant. We therefore assume that $p_{dt} = \gamma_{p_d}^t p_{d0}$ and $w_t = \gamma_w^t w_0$, where $\gamma_{p_d} > 0$ and $\gamma_w > 0$ are exogenous growth rates, and p_{d0} and w_0 are initial conditions. In Appendix (C), we provide a potential microfoundation for the growth rates γ_w and γ_{p_d} that involves the production

[31] The model uses non-recreation consumption as the numeraire. However, a price index for these items is not readily available for all the countries in our sample, so in our empirical exercises we normalize nominal terms by all-item price indices. The discrepancy between the two is unlikely to be large because recreation expenditures typically account for less than 10% of the overall consumption spending. For the U.S. the all-item and non recreation price series follow each other closely.

sector of the economy.

On a balanced-growth path, c_t, d_t and h_t also grow at constant (endogenous) rates, denoted by g_c, g_d and g_h. Since hours worked are naturally bounded by the time endowment we focus on the case in which $g_h \leq 1$. These growth rates might depend, in turn, on the growth rates of the fundamentals γ_w and γ_{p_d}, and perhaps on other features of the economy. The budget constraint of the household imposes some restrictions on these endogenous growth rates. For (6) to be satisfied in every period, each term must grow at the same rate and it must therefore be that

$$g_c = \gamma_{p_d} g_d = \gamma_w g_h. \tag{7}$$

3.3 Balanced-growth path preferences

Another set of restrictions on the growth rates comes from the preferences of the household. For instance, under the utility function introduced by King et al. (1988), hours worked h_t must remain constant over time which implies that consumption and the wage grow at the same rate: $g_c = \gamma_w$. Boppart and Krusell (2020) generalize these preferences to let hours worked grow on a balanced-growth path and the growth rate of consumption can take the more general form $g_c = \gamma_w^{1-\nu}$, where ν is a parameter of the utility function. In our case, the growth rate of consumption might also be affected by the growth rate of recreation prices, γ_{p_d}, and we therefore consider the more general form

$$g_c = \gamma_w^{\eta} \gamma_{p_d}^{\tau}, \tag{8}$$

where η and τ are constants that have to be determined.

We can combine equations (7) and (8) to characterize the growth rates of all the endogenous quantities in terms of the constants η and τ such that

$$\begin{aligned} g_c &= \gamma_w^{\eta} \gamma_{p_d}^{\tau}, \\ g_h &= \gamma_w^{\eta-1} \gamma_{p_d}^{\tau}, \\ g_d &= \gamma_w^{\eta} \gamma_{p_d}^{\tau-1}. \end{aligned} \tag{9}$$

Given these restrictions, we can formally define the properties of a utility function that is consistent with a balanced-growth path in this economy.[32]

Definition 1 (Balanced-growth path preferences)**.** The utility function u is *consistent with a balanced-growth path* if it is twice continuously differentiable and has the following properties: for any $w > 0$, $p > 0$, $c > 0$, $\gamma_w > 0$ and $\gamma_p > 0$, there exist $h > 0$, $d > 0$ and $r > -1$ such that for

[32] The following definition is a generalization of Assumption 1 in Boppart and Krusell (2020). We focus on the case $\eta > 0$ and $\tau > 0$. From (9) we see that when $\eta < 0$ higher wage growth leads to lower consumption growth. When $\tau < 0$ higher growth in the price of recreation goods leads to smaller growth in hours. We therefore focus on the parameterizations that are more empirically relevant.

any t

$$-\frac{u_h\left(c\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right)^t, h\left(\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\right)^t, d\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)^t\right)}{u_c\left(c\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right)^t, h\left(\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\right)^t, d\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)^t\right)} = w\gamma_w^t, \tag{10}$$

$$\frac{u_d\left(c\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right)^t, h\left(\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\right)^t, d\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)^t\right)}{u_c\left(c\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right)^t, h\left(\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\right)^t, d\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)^t\right)} = p_d\gamma_{p_d}^t, \tag{11}$$

and

$$\frac{u_c\left(c\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right)^t, h\left(\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\right)^t, d\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)^t\right)}{u_c\left(c\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right)^{t+1}, h\left(\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\right)^{t+1}, d\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)^{t+1}\right)} = \beta\left(1+r\right), \tag{12}$$

where $\eta > 0$ and $\tau > 0$.

These equations are the usual first-order conditions of the household. The first one states that the marginal rate of substitution between hours h_t and consumption c_t must equal the wage w_t, the second equation states that the marginal rate of substitution between leisure goods d_t and consumption c_t must equal the price of leisure goods p_t, and the third equation is the intertemporal Euler equation. Definition 1 imposes that these optimality conditions must be satisfied in every period t, starting from some initial point $\{c, h, d, p_d, w\}$ and taking into account the respective growth rates of each variable provided by (9).

The following proposition describes the class of utility functions that are consistent with a balanced-growth path.

Proposition 1. *The utility function $u(c,h,d)$ is consistent with a balanced-growth path (Definition 1) if and only if (save for additive and multiplicative constants) it is of the form*

$$u\left(c,h,d\right) = \frac{\left(c^{1-\varepsilon}d^{\varepsilon}v\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right)\right)^{1-\sigma}-1}{1-\sigma}, \tag{13}$$

for $\sigma \neq 1$,

$$u\left(c,h,d\right) = \log\left(c^{1-\varepsilon}d^{\varepsilon}\right) + \log\left(v\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right)\right), \tag{14}$$

for $\sigma = 1$, and where v is an arbitrary twice continuously differentiable function and where $\eta > 0$ and $\tau > 0$.

Proof. The proof is in Appendix D. □

This proposition establishes necessary and sufficient conditions on the shape of u so that it is consistent with a balanced-growth path. They are the only restrictions that we impose on the utility function, such that our analysis remains general and does not hinge on a particular choice of u.[33] Of course, several utility functions that satisfy (13)–(14) make little economic sense. Additional restrictions would need to be imposed so that, for instance, u is increasing in c and decreasing in h. But we do not need to explicitly specify these restrictions. For our analysis to hold, we only need that the household maximizes some version of (13)–(14), and that the first-order conditions are necessary to characterize its optimal choice.[34]

Several utility functions that have been used in the literature are nested in (13)–(14). For instance, the standard balanced-growth preferences of King et al. (1988) in which labor remains constant can be obtained by setting $\varepsilon = 0$, $\tau = 0$ and $\eta = 1$. To allow for a nonzero income effect of rising wages on the labor supply, we can instead set $\varepsilon = 0$, $\tau = 0$ and $\eta \neq 0$ to get the preferences of Boppart and Krusell (2020).[35,36]

3.4 The impact of w and p_d

Proposition 1 also shows that the constants η and τ introduced as placeholders in (8) can come directly from the utility function. As such, they do not depend on other (perhaps endogenous) economic variables whose presence might lead to endogeneity issues in our estimation. From (9), we therefore have a system of three equations

$$\begin{aligned} \log g_c &= \eta \log \gamma_w + \tau \log \gamma_{p_d}, \\ \log g_d &= \eta \log \gamma_w + (\tau - 1) \log \gamma_{p_d}, \\ \log g_h &= (\eta - 1) \log \gamma_w + \tau \log \gamma_{p_d}. \end{aligned} \tag{15}$$

to be estimated in the following section.

These equations show that the log of the growth rates of the endogenous variables c_t, d_t and h_t are linear relationships in the log of the growth rates of the exogenous variables w_t and p_{dt}, and that the preference parameters η and τ characterize these relationships. These parameters capture the intensity of standard income and substitution effects, triggered by changes in prices, that are at work in the model.

[33] Proposition 1 extends Theorems 1 and 2 in Boppart and Krusell (2020). These theorems establish necessary and sufficient conditions on the shape of u for consistency with a balanced-growth path in an environment without recreation goods.

[34] Our analysis goes through even if the utility function (13)–(14) is not concave. In this case, the first-order conditions are not sufficient to characterize a solution to the household's optimization problem but they are still necessary. As a result, they are satisfied at the household's optimal decision and we can use them to characterize the balanced-growth path.

[35] Our preferences, however, do not nest some other utility functions that have recreation goods and services as an input. For instance, the preferences used by Kopecky (2011) and Vandenbroucke (2009) do not allow for balanced growth and are therefore not a special case of (13)–(14).

[36] We can compute the Frisch elasticity of labor supply associated with the utility function (13)–(14) and show that it is constant along the balanced-growth path. Although it is not, in general, only a function of the parameters of the utility function.

The third equation plays a central role in our exploration of the causes behind the decline in work hours. The first term on its right-hand side captures how rising wages affect the supply of labor. When $\eta - 1 < 0$, higher wage growth lead to more leisure growth through a standard income effect: richer households substitute consumption with leisure. When instead $\eta - 1 > 0$, the substitution effect dominates and the household takes advantage of the higher wage rate to work more and earn more income. The second term on the right-hand side of the equation captures the impact of falling recreation prices on labor supply. When $\tau > 0$, a decline in the price of recreation goods and services incentivizes the household to enjoy more leisure and work less.

Overall, the results of this section provide a clear path to empirically evaluate the importance of the decline in recreation prices on hours worked. From (15), we know that g_c, g_d and g_h are related log-linearly to γ_w and γ_{p_d}, so that we can estimate these relationships readily through standard linear techniques. Furthermore, these relationships are structural, so that we can be sure that our estimation captures deep parameters that are unaffected by changes in policy.[37] Proposition 1 also shows that the relationship between hours worked and leisure prices is invariant to various features of the utility function, such as the function v and the parameters ε and σ. As a result, we can be confident that our empirical strategy is robust to a broad class of utility functions. Finally, our analysis does not hinge on a particular set of assumptions about the production sector of the economy, as long as w_t and p_{dt} grow at constant rates. As such, it is robust to different production technologies, market structures, etc. We nonetheless provide in Appendix C an example of a production structure that provides a microfoundation in which the constant growth rates γ_w and γ_{p_d} depend on underlying productivity growth in the non-recreation and recreation sectors.

4 Measuring the impact of the decline in leisure prices

We now turn to the structural estimation of the model. Our focus is on the system of equations (15), which relates the growth rates of hours, recreation consumption and non-recreation consumption to the growth rates of wages and recreation prices. The advantage of focusing on this system of equations is that it allows us to impose the key restrictions implied by the structural model without having to provide the complete description of the economy, i.e. the full specification of preferences, technology, etc. We estimate the model on both the cross-section of countries and on the household-level data from the United States that we introduced in Section 2.

4.1 Cross-country estimation

We begin by considering the cross section of countries. Denote by $\Delta \log c_i$, $\Delta \log d_i$ and $\Delta \log h_i$ the average annual growth rates, over the whole sample, of non-recreation consumption, recreation

[37] Note also that the third equation in (15) justifies our use of a linear specification in the previous section.

consumption and hours worked.[38] We use a generalized method of moment method to estimate the system

$$\begin{aligned}\Delta \log c_i &= \alpha^c + \eta \Delta \log w_i + \tau \Delta \log p_i + \varepsilon_i^c, \\ \Delta \log d_i &= \alpha^d + \eta \Delta \log w_i + (\tau - 1) \Delta \log p_i + \varepsilon_i^d, \\ \Delta \log h_i &= \alpha^h + (\eta - 1) \Delta \log w_i + \tau \Delta \log p_i + \varepsilon_i^h,\end{aligned} \tag{16}$$

where $\Delta \log w_i$ and $\Delta \log p_i$ are the growth rates of real wages and real recreation prices, and where the ε's are error terms. We also include the constants α^c, α^d and α^h to absorb potential aggregate changes in the data that were not explicitly included in the model.

Estimating the system of equation 16 has several advantages. First, it has been derived from a structural model which lessens worries about misspecification. The estimated coefficients are also deep parameters of the model and can be thought of as exogenous. Second, the system (17) exploits cross-equation restrictions to further discipline the estimation. For instance, in contrast to the regressions of Tables 1 and 2, consumption data helps to pin down the coefficients that relate changes in recreation prices and wages to hours worked.

The results are presented in Table 3. The first column shows the estimates of the coefficients τ and $\eta - 1$ when real GDP per hour is used as a proxy for wages. Columns (2) and (3) show the estimated coefficients under alternative measures for wages: real employee compensation per hour in column (2) and real GDP per capita in column (3). We can see that the results are similar across specification. Overall, we find a significantly positive coefficient τ, which, from (16), is consistent with cheaper recreation items having a negative impact on hours per capita.

We also find a negative and strongly significant value for $\eta - 1$, which is consistent with a dominant income effect of rising wages on hours worked. This last result is in contrast with the findings of Table 1 where the association between wages and hours was mostly insignificant. In the current exercise, the consumption data together with the model restrictions impose enough discipline to make the income effect visible. To understand why, notice from (16) that a dominating substitution effect ($\eta - 1 > 0$) implies that consumption growth reacts more than one for one to a change in wage growth. Intuitively, higher wages not only lead to additional income keeping hours fixed but they also raise hours leading to an extra increase in income. That additional income leads to a larger increase in recreation and non-recreation consumption. The data rejects such a strong effect of wage growth on consumption and so the estimation finds that the income effect is dominant.

Finally, Table 3 shows that the constant α^h is positive and significantly different than zero. This constant absorbs aggregate changes such as the secular increase in female labor force participation

[38] Consumption data are from the OECD and Eurostat and are described in more details in Appendix A.2. Since the model does not feature population growth, we normalize consumption variables and hours by the working age population (25 to 64 years old). We provide robustness on that normalization in Appendix B.3.

or demographic trends that are not explicitly included in the model.[39]

	(1)	(2)	(3)
τ	0.258^{***}	0.225^{***}	0.177^{**}
	(0.078)	(0.080)	(0.074)
$\eta - 1$	-0.430^{***}	-0.253^{***}	-0.366^{***}
	(0.071)	(0.052)	(0.052)
α^h	0.012^{***}	0.008^{***}	0.009^{***}
	(0.002)	(0.002)	(0.002)
Wages	GDP per hour	Empl. comp. per hour	GDP per capita
Observations	41	41	41

Results of iterative GMM estimation of (16). Robust standard errors in parentheses. *,** ,*** indicate significance at the 10%, 5%, and 1% levels, respectively. Variables are constructed using all years except for 2008 and 2009. Work hours are measured in per capita terms. Population includes individuals between 25 and 64 years old.

Table 3: GMM estimation of (16) using hours per capita.

While the model is concerned with the overall labor supply of the representative household, we can use the system (16) to evaluate the impact of recreation prices on the intensive margin by using hours per worker for $\Delta \log h_i$. We do so in Table B.3 in the Appendix. We find a positive and mostly significant coefficient τ, suggesting that recreation prices also affect the intensive margin of labor supply. We also find a negative effect of wages on hours worked in all the specifications we consider.

4.2 Cross-household estimation

We now estimate the model using the household-level data described in Section 2.3 and using our instruments to address potential endogeneity issues similar to those mentioned in Section 2. The system of equations is

$$\begin{aligned} \Delta \log c_g &= \alpha^c + \eta \Delta \log w_{gl} + \tau \Delta \log p_g + \varepsilon^c_{gl}, \\ \Delta \log d_g &= \alpha^d + \eta \Delta \log w_{gl} + (\tau - 1) \Delta \log p_g + \varepsilon^d_{gl}, \\ \Delta \log h_{gl} &= \alpha^h + (\eta - 1) \Delta \log w_{gl} + \tau \Delta \log p_g + \varepsilon^h_{gl}, \end{aligned} \tag{17}$$

where $\Delta \log x_{gl}$ denotes the log growth rate of a variable x for households in an age-education group g in location l between 1990 and the 2014-2018 period. As in Section 2.3, we instrument for the wage by using a Bartik-like instrument that captures how aggregate changes in industry-level wages affects labor earning in different location. Similarly, we take advantage of differences in the composition of recreation consumption baskets across households with different education levels

[39] The constants α^c and α^d are also significantly larger than zero although the point estimates are smaller than for α^h.

and ages to construct an instrument for recreation prices.Notice that non-recreation consumption, recreation consumption and recreation prices do not vary across locations due to data limitations.

The estimated coefficients τ and $\eta - 1$ are presented in Table 4. Column 1 shows the estimates without instruments while column 2 shows the outcome of the instrumental variable estimation.[40] In both cases, we find that the τ coefficients are significantly above zero, again suggesting that the decline in recreation prices makes leisure time more attractive and, thus, leads to a reduction in work hours. We also find in both columns that $\eta - 1$ is estimated to be significantly negative, although its value is somewhat smaller in absolute terms with the instruments. Going back to the third equation in (15), this implies that higher wage growth leads to smaller growth in work hours. In other words, the preferences of the household are such that the income effect dominates.

	(1)	(2)
τ	0.360^{***}	0.387^{***}
	(0.044)	(0.047)
$\eta - 1$	-0.629^{***}	-0.276^{***}
	(0.009)	(0.080)
α^h	0.008^{***}	0.007^{***}
	(0.001)	(0.001)
Instruments	N	Y
Observations	10,469	10,469

Results of iterative GMM estimation of (17). Whenever iterative procedure does not converge, two-step procedure is used. Standard errors account for an arbitrary correlation within education-age groups and regions. They are reported in parentheses. *,** ,*** indicate significance at the 10%, 5%, and 1% levels, respectively. Column (2) uses Bartik-like instruments for wages and recreation prices.

Table 4: GMM estimation of the system (17).

4.3 Discussion

We can perform some back-of-the-envelope calculations to evaluate the importance of wage growth and the fall in recreation prices for the global decline in work hours. For that purpose, we will take the average values of the estimated coefficients in Table 3 which are $\tau = 0.22$ and $\eta - 1 = -0.35$. From Table 7 in the Appendix, we see that the annual growth rate of wages has been 2.45% across the countries in our sample, and that the equivalent number for recreation prices is -1.48%. Our results therefore suggest that wage growth has pushed for a decline in the growth rate of hours of about $2.45\% \times 0.35 \approx 0.86\%$ per year. Similarly, the decline in recreation prices can account for a decline in the growth of hours of about $1.48\% \times 0.22 \approx 0.33\%$ per year. Based on these calculations, the recreation channel has been about half as important as the income effect

[40] Column 1 reports the results of a two-step GMM estimation as the iterative procedure does not converge. Column 2 uses iterative GMM. The results are similar if the two-step procedure is used for column 2 (with both τ and $\eta - 1$ being statistically significant but slightly closer to zero).

as a driver of the decline in work hours.

Put together, these two channels would suggest that the average annual growth rate of work hours should be about -1.2%, more than the actual annual movement in hours per capita (-0.37%) and hours per worker (-0.60%) observed since 1950 and reported in Table 7. What explains this discrepancy? Clearly, the intercept α_h in 4 plays a non-trivial role, capturing for instance the entry of women into the labor force. We can filter out that effect by looking at male employment in the United States, for which data is readily accessible. From Figure 1a, we see that male hours per capita have gone down by about 0.25% per year since 1979. From the CPS, we find that the median real weekly earnings for males have been essentially unchanged over the same period, so that wage growth had approximately no impact on male labor supply decisions over that period. Since recreation prices have gone down by 0.70% a year in the last forty years in the U.S., the predicted impact of the decline in recreation prices ($-0.70 \times 0.22 = 0.15\%$ per year), which is more than half of the decline in male work hours.

5 Conclusion

We analyze the role of the declining prices of recreation goods in driving the downward trend in hours worked over the recent decades, both in the U.S. and across OECD countries. We provide a general specification of preferences that are consistent with balanced growth, and show that they imply a set of cross-equation restrictions on the growth rates of wages, recreation good prices, labor hours, and consumption of recreation as well as non-recreation goods. Taking these to the data we find that a large fraction of the decline in hours worked in the U.S. can be attributed to the falling price of recreation goods.

While we focus on the choice between supplying labor and enjoying leisure, the reality of household time use is surely more complex. An important branch of the literature has paid particular attention to the role of home production. Much of it argues that the increased productivity of market work relative to non-market work, as well as the reduction in the price of goods such as household appliances have pushed towards an increase in market hours and, in particular, to the entry of women into the labor force (Greenwood and Vandenbroucke, 2005). At the same time, recent evidence points to the growing importance of spending time with children, primarily among highly-educated households (Guryan et al., 2008; Ramey and Ramey, 2010; Dotti Sani and Treas, 2016). Accounting for these mechanisms should provide a more complete picture of the forces affecting labor supply.

Finally, recent evidence by Aguiar et al. (2017) shows that young men increasingly stay at home to play video games instead of working or attending school. Our evidence together with theirs suggests that declining recreation prices might disincentivize human capital accumulation, and thus slow down the movement towards a more highly-skilled workforce. Introducing this mechanism into macroeconomic models of skill acquisition, such as Kopytov et al. (2018), might improve their performance in matching the employment data. Exploring these forces in detail is an exciting avenue for future research.

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Appendices

A Data

This appendix contains the precise data sources and the steps that we took to construct the datasets.

A.1 United States data

For the United States, we rely on three datasets to conduct our cross-household exercises. The price data comes from the Bureau of Labor Statistics. Data on hours worked and wages are from the U.S. Census and the American Community Surveys. The consumption data is from Consumer Expenditure Survey. We describe how we use these datasets in Appendix A.1.1. In Appendix A.1.2, we describe the construction of long-run aggregate time series used in Section 2.1.

A.1.1 Data used in the cross-household analysis

Bureau of Labor Statistics The price data is from the Bureau of Labor Statistics (BLS). The all-item Consumer Price Index (CPI) series are encoded as 'CUUR0000SA0'. This series is used as deflator for all nominal variables. Recreation CPI series are encoded as 'CUUR0000SAR' and are available starting from 1993. Before 1993, we use the price index for the 'Entertainment' group, encoded as 'MUUR0000SA6', which is available between 1967 and 1997.

For our cross-household analysis in Section 2.3, we construct price indices for seven subcategories of recreation goods and services. The BLS changed their classification of goods and services in 1993; we try to map pre- and post-1993 price series as close as possible to ensure consistency over time. Table 5 shows the price items that we use in the pre- and post-1993 periods. For a few subcategories (Other goods, Pets, Photo, Reading, Sports), the price series were not changed in 1993 and are available for the entire sample.[41] While there does not seem to be any major change in the "Other services" subcategory in 1993, there is no unique price series that covers the entire sample. We therefore smoothly paste the price indices 'SE62' (pre-1993) and 'SERF' (post-1993). For 'Audio-video' in the pre-1993 sample, we aggregate 'SE31' (video and audio products) with 'SE2703' (cable television) using corresponding consumption shares from the Consumer Expenditure Surveys. We smoothly paste the resulting series with 'SERA' (post-1993) to get the price series over the entire sample.

[41] In the post-1993 period, some of these subcategories feature a few new items (for example, veterinary services were added to the 'Pets' subcategory, encoded by 'SERB02'). We do not include these new additions to make the price indices as comparable across the pre- and post-1993 periods as possible.

	Pre-1993 code	Post-1993 code	Notes
Audio-video	SE31 and SE2703	SERA	SE31: Video and audio products SE2703: Cable television
Other goods	SE6101	SERE01	
Other services	SE62	SERF	
Pets	SE6103	SERB01	
Photo	SE6102	SERD01	
Reading	SE59	SERG	
Sports	SE60	SERC	

Table 5: Prices of recreation goods and services before and after 1993.

Consumer Expenditure Survey For consumption categories, we follow Aguiar and Bils (2015) as closely as possible, so we refer the reader to their data construction section for a detailed description. One difference however is that we construct recreation consumption for seven different subcategories. In the CE, the consumption categories are coded using Universal Classification Codes, UCCs. Table 6 shows the UCCs corresponding to the seven recreation consumption subcategories.

	Universal Classification Codes
Audio-video	270310, 270311, 310110-310350, 310400, 340610, 340902, 340905, 610130, 620904, 620912, 620930, 620916-620918
Other goods	610110, 610140, 610120, 610130
Other services	610900-620111, 620121-620310, 620903
Pets	610320, 620410, 620420
Photo	610210, 620330, 620906, 610230, 620320
Reading	660310, 590110-590230, 590310, 590410, 690118
Sports	520901, 520904, 520907, 600131, 600132, 600141, 600142, 600110-600122, 600210-609999, 620906-620909, 620919-620922, 620902, 600127, 600128, 600137, 600138

Table 6: Recreation consumption subcategories.

Similarly to Aguiar and Bils (2015), we consider only households with reference persons of ages between 25 and 64 that completed 4 quarterly interviews within a year. We exclude households with extremely large expenditure shares on generally small consumption categories. We exclude households with nonzero wage and salary income ('FSALARYX') and zero hours ('INC_HRS1' multiplied by 'INCWEEK1' plus 'INC_HRS2' multiplied by 'INCWEEK2'). We also exclude households with zero wage and salary income and nonzero hours. To construct consumption baskets across age-education groups, we use age and education of reference persons.

United States Census and American Community Survey Hours are measured as 'UHRSWORK' multiplied by 'WKSWORK1'. When 'WKSROWK1' is unavailable (the ASC sample of 2014-2018), we use projected values of 'WKSWORK2' on 'WKSWORK1'. The measure of wage is 'INCWAGE'. Geographic regions are constructed using the cross-walk files from David Dorn's website (`https://www.ddorn.net/data.htm`). Industry classification is based on 'IND1990' and includes 34 industries: Agriculture, Forestry, and Fisheries; Mining; Construction; Manufacturing (19 subcategories); Transportation; Communications; Utilities and Sanitary Services; Wholesale Trade (2 subcategories); Retail Trade; Finance, Insurance, and Real Estate; Business and Repair Services; Personal Services; Entertainment and Recreation Services; Professional and Related Services; Public Administration.

For our cross-household regressions in Section 2.3, we also use disability indicators. The U.S. Census does not provide a consistent disability measure throughout our sample. For 1980, we use 'DISABWRK' that indicates whether respondents have any lasting condition that causes difficulty working. For 1990 and 2016, we use 'DIFFCARE' that indicates whether respondents have any lasting condition that causes difficulty to take care of their own personal needs, and 'DIFFMOB' that indicates whether respondents have any lasting condition that causes difficulty to perform basic activities outside the home alone.

A.1.2 Data used to construct the long-run series

Prices Early data on real recreation prices comes from Owen (1970) (Table 4-B, pages 85-86, the data covers the period between 1901 and 1961). The data between 1935 and 1970 is from the Bureau of the Census (1975) (page 210, column 'Reading and recreation' divided by column 'All items'). Between 1967 and 1992, data on recreation prices comes from BLS (series 'MUUR0000SA6'). Starting from 1993, BLS provides a new series on recreation prices, encoded as 'CUUR0000SAR'. The BLS data is deflated using the all-item CPI series, encoded as 'CUUR0000SA0'.

Hours, wages and population Early data on average weekly hours is from the Bureau of the Census (1975) (series 'D765' and 'D803'). For the postwar sample, the data is available from the FRED website of the St. Louis Fed (series 'PRS85006023').

Early data on total hours worked is from Kendrick et al. (1961) (table A-X) and Kendrick et al. (1973) (table A-10). Early data on population by age comes from the U.S. Census (available at `https://www.census.gov/data/tables/time-series/demo/popest/pre-1980-national.html`). Recent data on hours worked and population is from ASEC. Following Cociuba et al. (2018), we compute average weighted annual hours worked using the variable ‘ahrsworkt’. Population is constructed by summing ‘asecwt’.

Early data on labor productivity (wages) is from Kendrick et al. (1961) (table A-I; real gross national product, normalized by hours worked). From 1929, FRED provides data on compensation of employees (series ‘A033RC1A027NBEA’), which we normalize by total hours worked and CPI (FRED series ‘CPIAUCNS’), which is the same as reported by the BLS in ‘CUUR0000SA0’.

Consumption and labor income To construct the consumption shares in Section 3.1, we use data from the NIPA tables. The consumption data is from Table 2.5.5 “Personal Consumption Expenditures by Function”. Recreation consumption is the sum of rows 75, 77, 78, 82, 90, 91, 92, 93, 94. We subtract $\frac{\text{row 76}}{\text{row 75+row76}} \times$ row 77 to exclude a computer-related component from row 77 (“Services related to video and audio goods and computers”). Total consumption expenditures is row 1. Data on personal income is from Table 2.1 “Personal Income and Its Disposition”. We use row 1 (total personal income) and row 2 (compensation of employees).

American Time Use Survey We use the American Time Use Survey for Figures 2 and 6. The variables are constructed as in Aguiar and Hurst (2007b) and Aguiar et al. (2017). We refer the reader to their extensive data description for further details.

A.2 Cross-country data

Our international data comes primarily from the OECD database and Eurostat. As mentioned in the main text, we restrict our sample to countries with at least 15 years of data on real recreation prices. Our final sample includes 42 countries shown in Table 7. Below, we describe how the variable are constructed in more details.

Prices For the majority of countries, the price data is from the OECD database, category ‘Prices and Purchasing Power Parities’. For a few countries, longer price series are obtained from different sources. The U.S. price data is described above. For Australia, the data comes from the Australian Bureau of Statistics, Catalogue Number 6401.0. For Canada, the data comes from Statistics Canada, Table 18-10-0005-01. For a few European countries, the data comes from the Eurostat’s Harmonized Index of Consumer Prices (HICP) dataset (which is also available at the OECD website). When several different series are available for the same variable (e.g., one from the OECD and one from Eurostat), we select the longer one.

Hours Hours data is from the Conference Board Total Economy Database.

Population and labor force statistics Population by age and sex is from the OECD database (‘Demography and population’ category). Labor force statistics by age and sex are from the OECD database ('Labour'-'Labour Force Statistics'-'LFS by sex and age').

Consumption, employee compensation and GDP These data are from the OECD and Eurostat. In the OECD database, it is available in the 'National Accounts' category. Total consumption expenditure is encoded as 'P31S14', recreation consumption is encoded as 'P31CP090'. To obtain non-recreation consumption, we subtract recreation consumption from total consumption. Compensation of employees is encoded as 'D1' and GDP is encoded as 'B1_GE'. Eurostat follows the same naming convention. When several different series are available for the same variable (one from the OECD and one from Eurostat), we select the longer one. All nominal series are deflated by all-item CPIs.

Summary Table Table 7 provides summary statistics for our multi-country dataset.

	Hours per capita		Hours per worker		Real wages		Real recreation price	
	Growth rate, %	Starting year	Growth rate, %	Starting year	Growth rate, %	Starting year	Growth rate, %	Starting year
Australia	−0.14	1950	−0.53	1966	1.53	1959	−1.41	1989
Austria	−0.40	1950	−0.49	1994	1.61	1970	−1.17	1996
Belgium	−0.49	1950	−0.61	1983	1.54	1970	−1.20	1996
Brazil	−0.37	1950	−0.56	2001	4.14	2000	−2.28	2002
Bulgaria	0.52	1995	−0.41	2000	4.51	1997	−2.36	1997
Canada	−0.32	1950	−0.50	1976	0.90	1970	−0.95	1950
Costa Rica	−0.41	1987	−0.83	1987	2.31	1991	−3.56	1995
Croatia	0.31	1995	−0.91	2007	1.36	1998	−0.81	1998
Cyprus	−0.83	1995	−0.84	2000	1.86	1996	−1.43	1996
Czechia	−0.57	1993	−0.76	1993	2.55	1993	−1.56	1995
Denmark	−0.61	1950	−0.26	1983	1.85	1967	−1.29	1996
Estonia	−0.18	1995	−0.69	1995	4.92	1996	−1.79	1996
Finland	−0.83	1950	−0.78	1963	2.43	1970	−1.05	1996
France	−0.98	1950	−0.71	1975	3.02	1955	−1.81	1990
Germany	−0.99	1950	−0.56	1991	1.98	1970	−1.02	1991
Greece	−0.45	1950	−0.42	1983	1.78	1970	−1.34	1996
Hungary	−0.93	1980	−0.87	1992	1.84	1995	−1.72	1996
Iceland	−0.69	1964	−0.62	1991	2.46	1976	−0.94	1996
Ireland	−0.73	1950	−1.40	1961	2.70	1976	−0.40	1983
Israel	0.34	1981	−0.19	1985	0.99	1995	−1.74	1985
Italy	−0.51	1950	−0.48	1970	1.28	1970	−0.96	1996
Japan	−0.57	1950	−0.66	1968	1.74	1970	−0.57	1970
Korea	−0.62	1960	−1.43	1980	6.57	1970	−2.57	1985
Latvia	0.33	1995	−0.43	2000	5.43	1995	−2.04	1995
Lithuania	0.70	1995	0.12	2000	4.91	1995	−2.28	1993
Luxembourg	0.78	1970	0.54	1983	2.18	1970	−0.47	1995
Malta	−0.31	1994	−1.64	2000	2.16	1996	−1.57	1996
Mexico	0.16	1950	−0.80	1991	−0.82	1970	−1.30	2003
Netherlands	−0.46	1950	−0.98	1971	1.01	1969	−1.37	1996
Norway	−0.44	1950	−0.54	1972	2.35	1970	−0.51	1979
Poland	−0.08	1993	−0.13	1993	2.67	1993	−1.54	1996
Portugal	−0.23	1950	−0.58	1974	1.63	1970	−1.03	1955
Romania	−1.24	1995	−0.99	2000	6.54	1996	−2.02	1996
Russia	0.11	1992	−0.35	1992	4.27	1992	−1.81	2004
Slovakia	−0.78	1990	−0.85	1994	2.11	1993	−1.48	1996
Slovenia	−0.35	1995	−0.45	2000	1.81	1995	−0.92	1996
Spain	−0.74	1950	−0.97	1972	1.73	1970	−1.95	1996
Sweden	−0.27	1950	−0.38	1963	1.72	1970	−1.68	1980
Switzerland	−0.40	1950	−0.32	1991	1.28	1970	−0.86	1983
Turkey	−1.15	1970	−0.20	1988	3.37	1998	−3.00	1996
United Kingdom	−0.43	1950	−0.47	1984	1.89	1970	−1.64	1988
United States	−0.07	1950	−0.41	1960	0.90	1970	−0.70	1950
Average	−0.37		−0.60		2.45		−1.48	

Columns "Growth rate [%]" report log-linear trend coefficients. The series are available between the starting year given in the "Starting year" column and 2018. The earliest starting year is 1950—the first year for hours worked in the Total Economy Database.

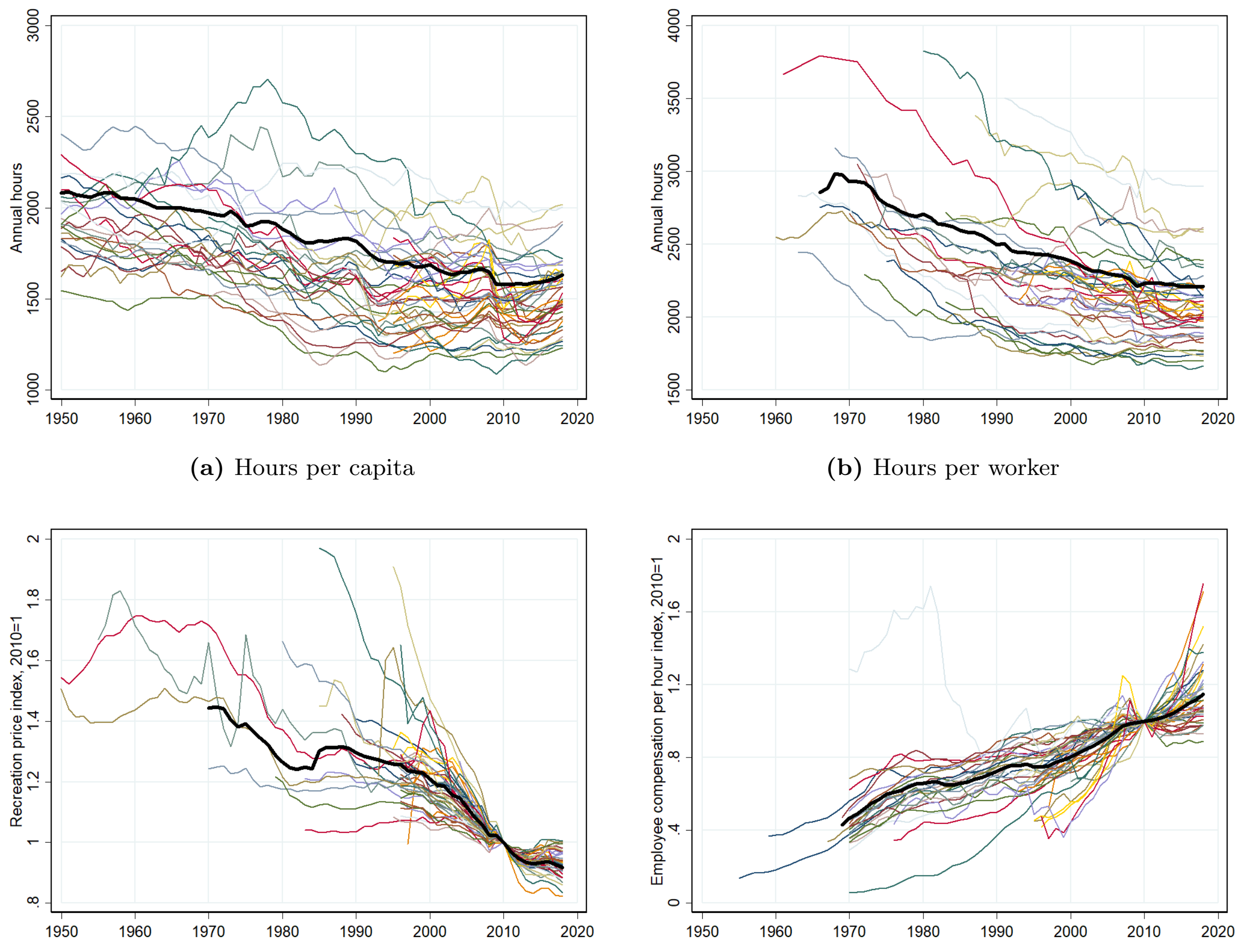
Table 7: Summary statistics for multi-country sample.

B Additional empirical results

This appendix provides various robustness tests for the results in the body of the paper as well as additional figures and exercises.

B.1 Additional figures for multi-country sample

In the main text, we present the time series of hours worked, recreation prices and wages for a selected group of countries. Figure 8 shows the same graphs for the entire cross-section of 42 countries.



(a) Hours per capita

(b) Hours per worker

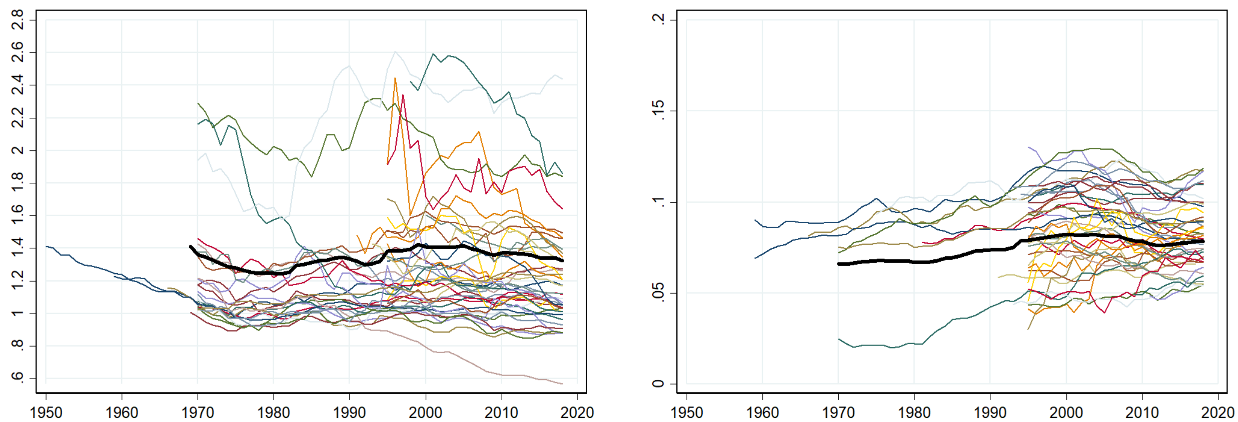
(c) Real recreation prices

(d) Real wages

The bold black lines show the year fixed effects from regressions of the corresponding variable on a set of country and year fixed effects, with all countries included. Regressions are weighted by country-specific total hours. For panels (a) and (b), the levels of the lines are normalized to all-country weighted averages in 2015. Panel (a): Annual hours worked over population between 25 and 64 years old. Source: Total Economy Database and OECD. Panel (b): Annual hours worked over number of employed between 25 and 64 years old. Source: Total Economy Database and OECD. Panel (c): Price of consumption for OECD category "Recreation and culture", normalized by price index for all consumption items. Base year = 2010. Source: OECD, Eurostat, national statistical agencies. Panel (d): Real compensation of employees divided by hours worked. Base year = 2010. Source: OECD, Eurostat and Total Economy Database.

Figure 8: Hours, wages and recreation prices in the international sample.

Figure 9 shows total consumption expenditures over labor income and recreation consumption share for the entire cross-section of countries. The consumption-labor income ratio is quite stable over time and does not trend upwards or downwards. The recreation consumption share is also fairly stable. In the earlier part of the sample, the slight increase is mostly driven by South Korea recovering from the Korean War.



(a) Consumption over income: International sample

(b) Recreation consumption share

Bold black curves show the year fixed effects from regressions of the corresponding variable on a set of country and year fixed effects, with all countries included. Regressions are weighted by country-specific total hours. The levels of bold black curves are normalized to all-country weighted averages in 2015. Panel (a): Total consumption expenditures over compensation of employees. Source: OECD and Eurosta. Panel (b): Fraction of recreation consumption in total consumption. Source: OECD and Eurostat.

Figure 9: Income, consumption and recreation consumption in the international sample.

B.2 Cross-country regressions

Hours per worker

In this section, we report regression results similar to those of Table 1 except that the dependent variable is the growth rate in hours per worker instead of hours per capita. The results are presented in Table 8.

Including the Great Recession

In this section, we replicate the results of Table 1 keeping the years 2008 and 2009 in the sample. The results are presented in Table 9.

Using ages 20 to 74

In this section, we replicate the results of Table 1 but using population between 20 and 74 at the denominator when computing hours per capita. The results are presented in Table 10.

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Growth in hours per worker $\Delta \log h$				
$\Delta \log p$	0.128	0.127	0.136	0.130	0.146
	(0.106)	(0.109)	(0.110)	(0.103)	(0.109)
$\Delta \log w$					
GDP per hour	−0.049			−0.080**	−0.034
	(0.041)			(0.039)	(0.051)
Empl. comp. per hour		−0.025			
		(0.031)			
GDP per capita			−0.002		
			(0.031)		
Female labor force part.				−0.274**	
				(0.103)	
Share of young male in pop.					−0.118
					(0.180)
R^2	0.072	0.051	0.040	0.334	0.104
Observations	41	41	41	41	41

Robust standard errors are in parentheses. *,** ,*** indicate significance at the 10%, 5%, and 1% levels, respectively. All variables are in growth rates. Growth rates are annual averages over all years except for 2008 and 2009. Population includes individuals between 25 and 64 years old.

Table 8: Cross-country regressions of hours per worker on recreation prices and wages.

B.3 Cross-country structural estimation

Hours per worker

In this appendix, we report estimation results similar to those of Table 3 except that we use hours per worker instead of hours per capita. The results are presented in Table 11.

Including the Great Recession

In this section, we replicate the results of Table 3 keeping the years 2008 and 2009 in the sample. The results are presented in Table 12.

Using ages 20 to 74

In this section, we replicate the results of Table 13 but using population between 20 and 74 years old when computing hours per capita. The results are presented in Table 13.

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Growth in hours per capita $\Delta \log h$				
$\Delta \log p$	0.273***	0.270***	0.301***	0.277***	0.260***
	(0.093)	(0.101)	(0.102)	(0.094)	(0.093)
$\Delta \log w$					
GDP per hour	−0.065			−0.056	−0.076
	(0.059)			(0.059)	(0.059)
Empl. comp. per hour		−0.043			
		(0.058)			
GDP per capita			0.033		
			(0.059)		
Female labor force part.				0.068	
				(0.081)	
Share of young male in pop.					0.095
					(0.101)
R^2	0.199	0.183	0.172	0.212	0.214
Observations	42	42	42	42	42

Robust standard errors are in parentheses. *,** ,*** indicate significance at the 10%, 5%, and 1% levels, respectively. All variables are in growth rates. Growth rates are annual averages over all years including 2008 and 2009. Population includes individuals between 25 and 64 years old.

Table 9: Cross-country regressions of hours per capita on recreation prices and wages including Great Recession years.

B.4 Household-level estimation

B.4.1 Derivation of equation (4)

We show here how to derive equation (4) in Section 2.3. We start from the definition of wages in a locality c for a demographic group d at time t:

$$w_{glt} = \frac{\sum_i e_{iglt}}{\sum_i h_{iglt}}.$$

It follows that we can write the growth rate of wages as

$$\frac{w_{glt+1}}{w_{glt}} = \frac{\frac{\sum_i e_{iglt+1}}{\sum_i e_{iglt}}}{\frac{\sum_i h_{iglt+1}}{\sum_i h_{iglt}}} = \frac{\sum_i \frac{e_{iglt}}{\sum_j e_{jglt}} \frac{e_{iglt+1}}{e_{iglt}}}{\sum_i \frac{h_{iglt}}{\sum_j h_{jglt}} \frac{h_{iglt+1}}{h_{iglt}}}.$$

The key idea behind our instrumental strategy is to replace the *local* growth in earnings and hours in the equation above by their national equivalent. We therefore write, after taking the log,

$$\Delta \log w_{glt}^{IV} = \log \left(\frac{w_{glt+1}}{w_{glt}}\right)^{IV} = \log \left(\sum_i \frac{e_{iglt}}{\sum_j e_{jglt}} \frac{e_{igt+1}}{e_{igt}}\right) - \log \left(\sum_i \frac{h_{iglt}}{\sum_j h_{jglt}} \frac{h_{igt+1}}{h_{igt}}\right)$$

	(1)	(2)	(3)	(4)	(5)
	Dependent variable: Growth in hours per capita $\Delta \log h$				
$\Delta \log p$	0.234**	0.240**	0.210**	0.277**	0.229**
	(0.109)	(0.109)	(0.101)	(0.110)	(0.110)
$\Delta \log w$					
GDP per hour	0.071			0.063	0.069
	(0.074)			(0.075)	(0.075)
Empl. comp. per hour		0.051			
		(0.066)			
GDP per capita			0.148***		
			(0.043)		
Female labor force part.				0.150	
				(0.206)	
Share of young male in pop.					0.039
					(0.222)
R^2	0.110	0.096	0.290	0.153	0.111
Observations	42	42	42	42	42

Robust standard errors are in parentheses. *,** ,*** indicate significance at the 10%, 5%, and 1% levels, respectively. All variables are in growth rates. Growth rates are annual averages over all years except for 2008 and 2009. Population includes individuals between 20 and 74 years old.

Table 10: Cross-country regressions of hours per capita (population between 20 and 74) on recreation prices and wages.

We can also write that expression as

$$\begin{aligned}
\Delta \log w_{glt}^{IV} &= \log\left(1+\sum_i \frac{e_{iglt}}{\sum_j e_{jglt}} \frac{e_{igt+1}-e_{igt}}{e_{igt}}\right) - \log\left(1+\sum_i \frac{h_{iglt}}{\sum_j h_{jglt}} \frac{h_{igt+1}-h_{igt}}{h_{igt}}\right) \\
&\approx \sum_i \frac{e_{iglt}}{\sum_j e_{jglt}} \frac{e_{igt+1}-e_{igt}}{e_{igt}} - \sum_i \frac{h_{iglt}}{\sum_j h_{jglt}} \frac{h_{igt+1}-h_{igt}}{h_{igt}} \\
&\approx \sum_i \frac{e_{iglt}}{\sum_j e_{jglt}} \Delta \log e_{igt+1} - \sum_i \frac{h_{iglt}}{\sum_j h_{jglt}} \Delta \log h_{igt+1}
\end{aligned}$$

where we have used the fact that $\log(1+x) \approx x$ and so

$$\Delta \log x_{it+1} = \log x_{it+1} - \log x_{it} = \log \frac{x_{it+1}}{x_{it}} = \log\left(1+\frac{x_{it+1}-x_{it}}{x_{it}}\right) \approx \frac{x_{it+1}-x_{it}}{x_{it}}.$$

B.4.2 Recreation consumption share across education levels

Figure 10 shows how recreation consumption baskets vary by the level of education attainment of household heads. We do observe substantial variation, with households with low-educated heads consuming disproportionally more of "Audio-video" items, and households with highly-educated

	(1)	(2)	(3)
τ	0.454^{***}	0.558^{***}	0.121
	(0.154)	(0.165)	(0.109)
$\eta - 1$	-0.388^{***}	-0.211^{***}	-0.531^{***}
	(0.058)	(0.041)	(0.055)
α^h	0.008^{***}	0.006^{***}	0.005^{***}
	(0.002)	(0.002)	(0.002)
Wages	GDP per hour	Empl. comp. per hour	GDP per capita
Observations	40	40	40

Results of iterative GMM estimation of (16). Robust standard errors in parentheses. *,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively. Variables are constructed using all years except for 2008 and 2009. Work hours are measured in per worker terms. Population includes individuals between 25 and 64 years old.

Table 11: GMM estimation of (16) using hours per worker.

	(1)	(2)	(3)
τ	0.164^{**}	0.212^{***}	0.124
	(0.070)	(0.073)	(0.076)
$\eta - 1$	-0.182^{***}	-0.149^{***}	-0.249^{***}
	(0.044)	(0.037)	(0.038)
α^h	0.005^{***}	0.005^{***}	0.005^{***}
	(0.001)	(0.001)	(0.001)
Wages	GDP per hour	Empl. comp. per hour	GDP per capita
Observations	41	41	41

Results of iterative GMM estimation of (16). Robust standard errors in parentheses. *,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively. Variables are constructed using all years including 2008 and 2009. Work hours are measured in per capita terms. Population includes individuals between 25 and 64 years old.

Table 12: GMM estimation of (16) using hours per capita including Great Recession years.

heads consuming disproportionally more of “Other services” items.

B.4.3 Regressions with wages and recreation prices only

In this section, we run regressions with either only wages or only recreation prices as dependent variables. Tables 14 and 15 report the results.

B.4.4 Using household heads instead of all individuals

In the baseline analysis, our measures of wages and hours from the Census are at the individual level. The CE data, however, is at the household level, and we use the demographic characteristics of reference persons to construct demographic-specific consumption baskets. In this Appendix, we construct hours and wages using the Census data on the household heads only (variable ‘RE-

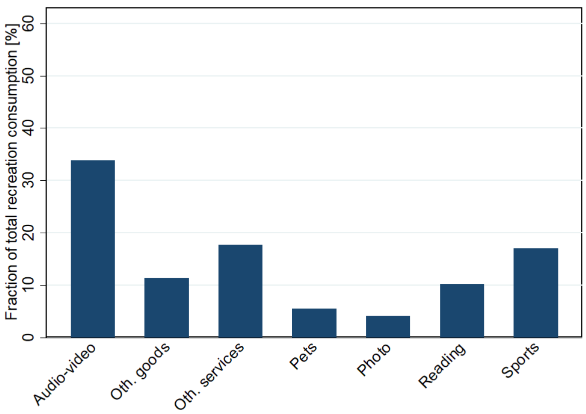
	(1)	(2)	(3)
τ	0.246^{***}	0.165^{**}	0.183^{**}
	(0.084)	(0.075)	(0.081)
$\eta - 1$	-0.426^{***}	-0.205^{***}	-0.382^{***}
	(0.068)	(0.042)	(0.053)
α^h	0.012^{***}	0.008^{***}	0.010^{***}
	(0.002)	(0.002)	(0.002)
Wages	GDP per hour	Empl. comp. per hour	GDP per capita
Observations	41	41	41

Results of iterative GMM estimation of (16). Robust standard errors in parentheses. *,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively. Variables are constructed using all years except for 2008 and 2009. Work hours are measured in per capita terms. Population includes individuals between 20 and 74 years old.

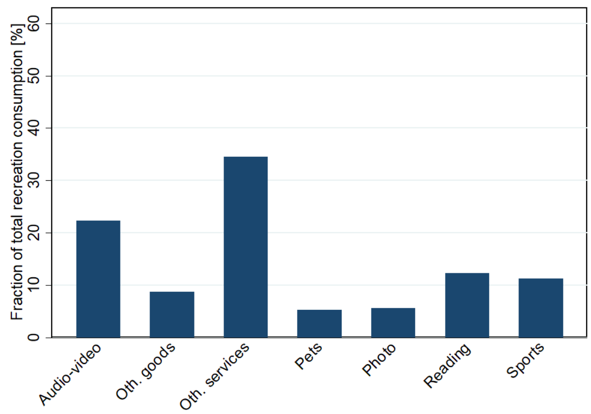
Table 13: GMM estimation of (16) using hours per capita (population between 20 and 74).

LATE'=1). To control for potentially very different consumption and labor supply choices across married and non-married household heads, we run regressions for all and married only household heads separately. Demographic controls include the 1980 shares of male, white, household heads with disabilities within each demographic-locality bin, as well as the 1990-2016 changes in these variables. In addition, we also control for the number of co-living children by computing the 1980 shares and the 1990-2016 changes in shares of household heads co-living with one, two, or more children below 18 years old. Table 16 shows the results.

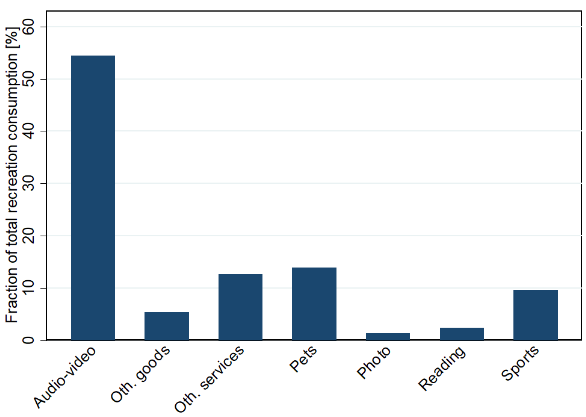
We also redo GMM estimation of system 17 for all and married only household heads. Results are given in Table 17. We find $\eta > 1$ when all household heads are considered. Crucially, the sign and magnitude of τ are quite similar to our baseline findings.



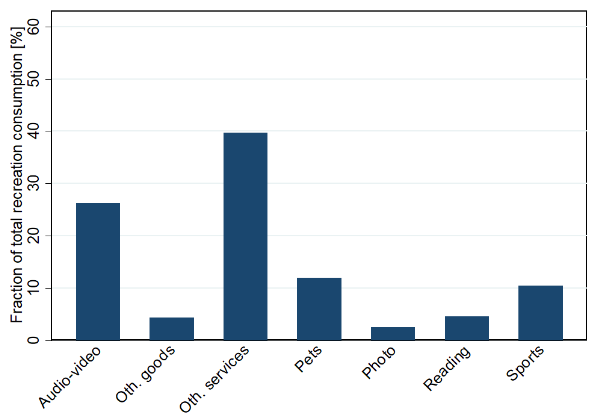
(a) No high school diploma, 1980-1988



(b) More than college, 1980-1988



(c) No high school diploma, 2010-2018



(d) More than college, 2010-2018

Shares of different items in total recreation consumption, constructed by pooling observations for the two periods, 1980-1988 and 2010-2018. Source: Consumer Expenditure Survey.

Figure 10: Share of recreation spending across education groups.

	(1): OLS	(2): OLS	(3): OLS	(4): IV	(5): IV	(6): IV
	Dependent variable: Growth in hours per capita $\Delta \log h$					
$\Delta \log w$	0.017	-0.063^{***}	-0.084^{***}	0.492^{***}	0.094^{**}	-0.196^{***}
	(0.015)	(0.013)	(0.013)	(0.044)	(0.042)	(0.046)
1980 manuf. hours			-0.336^{***}			-0.353^{***}
			(0.019)			(0.021)
Locality F.E.	Y	Y	Y	Y	Y	Y
Addtl. dem. cont.	N	Y	Y	N	Y	Y
F-statistics	—	—	—	427.3	379.4	320.9
R^2	0.259	0.435	0.467	—	—	—
Observations	10,469	10,469	10,469	10,469	10,469	10,469

Standard errors clustered at the locality level in parentheses. *,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively. F-statistics are Kleibergen-Paap. The regressions are across people sorted by locality/education-age group. Columns marked by "IV" use Bartik-like instruments for wages. Controls include manufacturing hours share in 1980 and a rich set of additional demographic controls (see text for details).

Table 14: Regressions of hours per capita on wages across locality/demographic-sorted households.

	(1): OLS	(2): OLS	(3): OLS	(4): IV	(5): IV	(6): IV
	Dependent variable: Growth in hours per capita $\Delta \log h$					
$\Delta \log p$	$0.407{*}{*}{*}$	$0.420{*}{*}{*}$	$0.151{*}{*}{*}$	$0.469{*}{*}{*}$	$0.494{*}{*}{*}$	$0.226{*}{*}{*}$
	(0.024)	(0.035)	(0.041)	(0.026)	(0.037)	(0.043)
1980 manuf. hours			-0.284^{***}			-0.264^{***}
			(0.023)			(0.023)
Locality F.E.	Y	Y	Y	Y	Y	Y
Addtl. dem. cont.	N	Y	Y	N	Y	Y
F-statistics	—	—	—	> 1000	> 1000	> 1000
R^2	0.302	0.446	0.463	—	—	—
Observations	10,469	10,469	10,469	10,469	10,469	10,469

Standard errors clustered at the locality level in parentheses. *,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively. F-statistics are Kleibergen-Paap. The regressions are across people sorted by locality/education-age group. Columns marked by "IV" use Bartik-like instruments for recreation prices. Controls include manufacturing hours share in 1980 and a rich set of additional demographic controls (see text for details).

Table 15: Regressions of hours per capita on recreation prices across locality/demographic-sorted households.

	(1): OLS	(2): OLS	(3): IV	(4): IV	(5): OLS	(6): OLS	(7): IV	(8): IV
	Dependent variable: Growth in hours per capita $\Delta \log h$							
	All household heads				Married only			
$\Delta \log p$	0.440***	0.350***	0.563***	0.533***	0.564***	0.491***	0.640***	0.593***
	(0.030)	(0.034)	(0.064)	(0.065)	(0.026)	(0.028)	(0.042)	(0.041)
$\Delta \log w$	−0.074***	−0.080***	−0.218***	−0.343***	−0.061***	−0.066***	−0.152***	−0.232***
	(0.013)	(0.013)	(0.060)	(0.067)	(0.012)	(0.012)	(0.046)	(0.051)
1980 manuf. hours		−0.126***		−0.169***		−0.099***		−0.124***
		(0.020)		(0.025)		(0.019)		(0.022)
Locality F.E.	Y	Y	Y	Y	Y	Y	Y	Y
Addtl. dem. cont.	Y	Y	Y	Y	Y	Y	Y	Y
F-statistics	—	—	105.4	82.8	—	—	125.6	103.2
R^2	0.405	0.409	—	—	0.390	0.393	—	—
# observations	9,458	9,458	9,458	9,458	8,233	8,233	8,233	8,233

Standard errors clustered at the locality level are in parentheses. *,**,*** indicate significance at the 10%, 5%, and 1% levels, respectively. F-statistics are Kleibergen-Paap. The regressions are across people sorted by locality/education-age group. Columns marked by "IV" use Bartik-like instruments for wages and recreation prices. Controls include manufacturing hours share in 1980 and a rich set of additional demographic controls (see text for details).

Table 16: Regressions of hours per capita on recreation prices and wages across locality/demographic-sorted households.

	(1)	(2)	(3)	(4)
	All household heads		Married only	
τ	0.424***	0.379***	0.493***	0.500***
	(0.100)	(0.101)	(0.104)	(0.107)
$\eta - 1$	−0.635***	0.200***	−0.669***	−0.596***
	(0.007)	(0.098)	(0.014)	(0.099)
α^h	0.003	0.003	0.002	0.002
	(0.002)	(0.002)	(0.002)	(0.002)
Instruments	N	Y	N	Y
Observations	9,458	9,458	8,233	8,233

Results of iterative GMM estimation of (17). Whenever iterative procedure does not converge, two-step procedure is used. Standard errors account for an arbitrary correlation within education-age groups and regions. They are reported in parentheses. *,** ,*** indicate significance at the 10%, 5%, and 1% levels, respectively. Columns (2) and (4) use Bartik-like instruments for wages and recreation prices..

Table 17: GMM estimation of the system (17).

C Production side of the economy

Our empirical analysis relies on the system of equations (15). As such, it is agnostic about how prices are determined in equilibrium as long as they grow at constant rates. In this section, we provide one example of a production structure that delivers these constant rates, and show how they depend on underlying productivity processes.

There are two competitive industries producing non-recreation and recreation goods c and d using Cobb-Douglas technologies

$$y_{jt} = A_{jt} l_{jt}^{\alpha} k_{jt}^{1-\alpha}, \tag{18}$$

where $j \in \{c, d\}$ denotes the industry, l_{jt} is labor, k_{jt} is capital and A_{jt} is Harrod-neutral total factor productivity. Consistent with our balanced-growth path framework, we assume that A_{jt} grows at an exogenous rate $\gamma_{A_j} > 0$ for $j \in \{c, d\}$. Labor and capital are perfectly mobile across industries and their prices are w_t and R_t. Firms maximize profits

$$\Pi_{jt} = p_{jt} y_{jt} - w_t l_{jt} - R_t k_{jt},$$

where p_{jt} is the price of good j at time t. As before, we use non-leisure consumption as the numeraire so that $p_{ct} = 1$ for all t, and the price of leisure goods p_{dt}, the wage w_t and the interest rate R_t are in units of non-leisure goods.

Investment goods are produced by a competitive industry using the production function $y_{it} = Ak_{it}$. Since these goods trade at a price p_{it}, the investment sector maximizes profits

$$\Pi_{it} = p_{it} A k_{jt} - R_t k_{jt}.$$

That sector is competitive such that $p_{it} A = R_t$ in equilibrium.

Market clearing implies that the demand for leisure and non-leisure goods is equal to their supply $y_{jt} = c_{jt}$ for $j \in \{c, d\}$. Similarly, the labor market clears, $h_t = l_{ct} + l_{dt}$, and so does the asset market $a_t = K_t$. The total stock of capital $K_t = k_{ct} + k_{lt} + k_{it}$ must also follow the law of motion

$$K_{t+1} = y_{it} + (1 - \delta) K_t,$$

where $0 < \delta < 1$ is the depreciation rate. Finally, the market rate of returns on assets has to equal the rental rate of capital net of depreciation, such that $r_t = R_t - \delta$.

We can now define an equilibrium in this economy.

Definition 2. A dynamic competitive equilibrium, is a time path of household's consumption, hours worked and asset position $\{c_t, d_t, h_t, a_t\}$; a time path for prices, wages, returns on asset and returns on capital $\{p_{dt}, p_{it}, w_t, r_t, R_t\}$ and a time path of factor allocations $\{l_{ct}, l_{dt}, k_{ct}, k_{dt}, k_{it}\}$ which satisfies household and firm optimization, perfect competition, resources constraints and market clearing.

The following proposition shows that, on a balanced-growth path, the growth rates of the leisure price p_{dt} and the wage w_t are constant and linked to the growth rates of the productivity processes A_c and A_d.

Proposition 2. *On a balanced-growth path, the growth rates of p_{dt} and w_t are*

$$\begin{aligned} \log \gamma_{p_d} &= \log \gamma_{A_c} - \log \gamma_{A_d}, \\ \log \gamma_w &= \alpha \log \gamma_{A_c}. \end{aligned} \tag{19}$$

This proposition shows that, since p_d is denominated in units of non-leisure goods, its growth rate captures how fast technological improvements occur in the leisure sector compared to the non-leisure sector. Similarly, productivity growth in the non-leisure sectors push wages higher.[42]

Combining (19) with (15) provides the growth rates of c, d and h has a function of the primitives γ_{A_c} and γ_{A_d}.

D Proofs

This section contains the formal results establishing restrictions on the shape of the utility function so that it be consistent with a balanced-growth path. The proofs follow mostly the same steps as Boppart and Krusell (2020) but must take care of an additional variable in the utility function.

The proof of Proposition 1 relies on the following two lemmata.

Lemma 1. *If $u(c,h,d)$ satisfies (10) and (11) for all $t>0$, $\gamma_w>0$ and $\gamma_{p_d}>0$, and for arbitrary $c>0$, $w>0$ and $p_d>0$, then its marginal rate of substitution functions, defined by $u_h(c,h,d)/u_c(c,h,d)$ and $u_d(c,h,d)/u_c(c,h,d)$ must be of the form*

$$\frac{u_h(c,h,d)}{u_c(c,h,d)} = \frac{c}{h} x\left(c^{1-\eta-\tau} h^{\eta} d^{\tau}\right) \tag{20}$$

and

$$\frac{u_d(c,h,d)}{u_c(c,h,d)} = \frac{c}{d} y\left(c^{1-\eta-\tau} h^{\eta} d^{\tau}\right) \tag{21}$$

where x and y are arbitrary functions, and η and τ are arbitrary numbers.

Proof. We beginning by showing how to derive (20). Set $t=0$ in (10) to find $-u_h(c,h,d)/$

[42] While γ_{A_d} does not show up in the equation for γ_w, improvements in the leisure technology still lower p_d which increases the purchasing power of each unit of the wage.

$u_c(c,h,d) = w$. Using that equation with (10) yields

$$\frac{u_h\left(c\lambda^{\eta}\mu^{\tau}, h\lambda^{\eta-1}\mu^{\tau}, d\lambda^{\eta}\mu^{\tau-1}\right)}{u_c\left(c\lambda^{\eta}\mu^{\tau}, h\lambda^{\eta-1}\mu^{\tau}, d\lambda^{\eta}\mu^{\tau-1}\right)} = \lambda\frac{u_h(c,h,d)}{u_c(c,h,d)}. \tag{22}$$

where we denote $\lambda = \gamma_w^t$ and $\mu = \gamma_{p_d}^t$ to simplify the expression. This equation must hold for every λ and μ.[43] For any given c and h, set $\lambda = h/c$ and $\mu = \left(c^{1-\eta}h^{\eta}\right)^{-1/\tau}$. These imply that $c\lambda^{\eta}\mu^{\tau} = 1$, $h\lambda^{\eta-1}\mu^{\tau} = 1$ and $d\lambda^{\eta}\mu^{\tau-1} = dh^{\frac{\eta}{\tau}}c^{-1+\frac{1}{\tau}(1-\eta)}$. From (22), we can therefore write

$$\frac{u_h\left(1,1,dh^{\frac{\eta}{\tau}}c^{-1+\frac{1}{\tau}(1-\eta)}\right)}{u_c\left(1,1,dh^{\frac{\eta}{\tau}}c^{-1+\frac{1}{\tau}(1-\eta)}\right)} = \frac{h}{c}\frac{u_h(c,h,d)}{u_c(c,h,d)}.$$

Now, define the function $x(t) = \frac{u_h\left(1,1,t^{1/\tau}\right)}{u_c\left(1,1,t^{1/\tau}\right)}$. We can rewrite this last equation as (20) which is the result.

We now turn to (21). Set $t = 0$ in (11) to find $u_d(c,h,d)/u_c(c,h,d) = p_d$. Combining with (11) yields

$$\frac{u_d\left(c\lambda^{\eta}\mu^{\tau}, h\lambda^{\eta-1}\mu^{\tau}, d\lambda^{\eta}\mu^{\tau-1}\right)}{u_c\left(c\lambda^{\eta}\mu^{\tau}, h\lambda^{\eta-1}\mu^{\tau}, d\lambda^{\eta}\mu^{\tau-1}\right)} = \mu\frac{u_d(c,h,d)}{u_c(c,h,d)} \tag{23}$$

where again $\lambda = \gamma_w^t$ and $\mu = \gamma_{p_d}^t$. Since this most old for any λ and μ, Set $\mu = d/c$ and $\lambda = \left(d^{\tau}c^{1-\tau}\right)^{-1/\eta}$ to find that $c\lambda^{\eta}\mu^{\tau} = 1$, $d\lambda^{\eta}\mu^{\tau-1} = 1$ and $h\lambda^{\eta-1}\mu^{\tau} = hd^{\frac{\tau}{\eta}}c^{-1+(1-\tau)\frac{1}{\eta}}$. We can therefore write (23) as

$$\frac{u_d\left(1, hd^{\frac{\tau}{\eta}}c^{-1+(1-\tau)\frac{1}{\eta}}, 1\right)}{u_c\left(1, hd^{\frac{\tau}{\eta}}c^{-1+(1-\tau)\frac{1}{\eta}}, 1\right)} = \mu\frac{u_d(c,h,d)}{u_c(c,h,d)}$$

Now, define the function $y(t) = \frac{u_h\left(1,t^{1/\eta},1\right)}{u_c\left(1,t^{1/\eta},1\right)}$. We can rewrite this last equation as (21) which completes the proof. □

We now turn to a Lemma that characterizes the second derivatives of u.

Lemma 2. *Under Definition 1, the second derivative of u must satisfy*

$$-\frac{cu_{cc}(c,h,d)}{u_c(c,h,d)} = z_1\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right) \tag{24}$$

$$-\frac{hu_{ch}(c,h,d)}{u_c(c,h,d)} = z_2\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right) \tag{25}$$

$$-\frac{du_{cd}(c,h,d)}{u_c(c,h,d)} = z_3\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right) \tag{26}$$

for arbitrary functions z_1, z_2 and z_3.

[43] Changing μ and λ involves changing a mixture of t, γ_w and γ_p. Changing t is innocuous as Definition 1 must hold for every t. Changing γ_w or γ_p would affect the interest rate r, but r does not show up here.

Proof. Since (12) must hold for all t, we can differentiate it with respect to t, divide the differentiated equation by (12) and set $t = 0$. Doing so we find

$$\frac{u_{cc}(c,h,d)\, c \log\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right) + u_{ch}(c,h,d)\, h \log\left(\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\right) + u_{cd}(c,h,d)\, d \log\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)}{u_c(c,h,d)} =$$

$$\frac{u_{cc}\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right) c\gamma_w^{\eta}\gamma_{p_d}^{\tau} \log\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right)}{u_c\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)} \tag{27}$$

$$+ \frac{u_{ch}\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right) h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau} \log\left(\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\right)}{u_c\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)}$$

$$+ \frac{u_{cd}\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right) d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1} \log\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)}{u_c\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)}.$$

Now differentiating (20) and (21) with respect to c, we find that $h\frac{u_{hc}(c,h,d)}{u_c(c,h,d)}$ and $d\frac{u_{dc}(c,h,d)}{u_c(c,h,d)}$ are functions of $c^{1-\eta-\tau}h^{\eta}d^{\tau}$ and $\frac{u_{cc}(c,h,d)}{u_c(c,h,d)}c$ only. We can write

$$h\frac{u_{hc}(c,h,d)}{u_c(c,h,d)} = f_1\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}, \frac{u_{cc}(c,h,d)}{u_c(c,h,d)}c\right)$$
$$d\frac{u_{dc}(c,h,d)}{u_c(c,h,d)} = f_2\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}, \frac{u_{cc}(c,h,d)}{u_c(c,h,d)}c\right)$$

and, since these equations holds for any c, h and d,

$$h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\frac{u_{hc}\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)}{u_c\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)} = f_1\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}, \frac{u_{cc}\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)}{u_c\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)}c\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right)$$
$$d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\frac{u_{dc}\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)}{u_c\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)} = f_2\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}, \frac{u_{cc}\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)}{u_c\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)}c\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right).$$

Plugging into (27) implies that

$$\frac{u_{cc}(c,h,d)\, c}{u_c(c,h,d)} = f_3\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}, \frac{u_{cc}\left(c\gamma_w^{\eta}\gamma_{p_d}^{\tau}, h\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}, d\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)}{u_c\left(c\gamma_w^{1-\nu}, h\gamma_w^{-\nu}, d\gamma_w^{-\tilde{\gamma}g(\nu)}\right)}c\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right), \tag{28}$$

where f_3 is an arbitrary function. This equation must hold for every γ_w and γ_p (r would also need to be adjusted, but r does not show up here). We can therefore set $\gamma_w = 1$ and $\gamma_p = 1$, and we find that $\frac{u_{cc}(c,h,d)c}{u_c(c,h,d)}$ only depends on $c^{1-\eta-\tau}h^{\eta}d^{\tau}$. $\square$

Proposition 1. *The utility function $u(c,h,d)$ is consistent with a balanced-growth path (Definition 1) if and only if (save for additive and multiplicative constants) it is of the form*

$$u(c,h,d)=\frac{\left(c^{1-\varepsilon}d^{\varepsilon}v\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right)\right)^{1-\sigma}-1}{1-\sigma} \tag{13}$$

for $\sigma\neq 1$, or

$$u(c,h,d)=\log\left(c^{1-\varepsilon}d^{\varepsilon}\right)+\log\left(v\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right)\right) \tag{14}$$

for $\sigma=1$, and where v is an arbitrary twice continuously differentiable function and where $\eta>0$ and $\tau>0$.

Proof. We first consider the "if" direction of the proof and then turn to the "only if" part. Consider the case with $1-\eta-\tau\neq 0$. From Lemma 2 we have

$$\frac{\partial\log\left(u_c(c,h,d)\right)}{\partial\log(c)}=-z_1\left(\exp\left((1-\eta-\tau)\log(c)+\eta\log(h)+\tau\log(d)\right)\right). \tag{29}$$

Integrating with respect to $\log c$ we find that

$$u_c(c,h,d)=f_4\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right)m_1(h,d) \tag{30}$$

where f_4 is a new function of $c^{1-\eta-\tau}h^{\eta}d^{\tau}$, and m_1 is an arbitrary function of h and d.

Now we can restrict m_1 since, from Lemma 2, $\frac{hu_{hc}(c,h,d)}{u_c(c,h,d)}$ and $\frac{du_{dc}(c,h,d)}{u_c(c,h,d)}$ are also only functions of $c^{1-\eta-\tau}h^{\eta}d^{\tau}$. Taking the derivative of (29) with respect to h, multiplying by h and dividing by u_c we obtain

$$\frac{hu_{hc}(c,h,d)}{u_c(c,h,d)}=\frac{f_4'\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right)c^{1-\eta-\tau}h^{\eta}d^{\tau}\eta}{f_4\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right)}+\frac{hm_{1,h}(h,d)}{m_1(h,d)}.$$

Similarly, we can take the derivative of (29) with respect to d, multiplying by d and dividing by u_c to find

$$\frac{du_{dc}(c,h,d)}{u_c(c,h,d)}=\frac{f_4'\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right)c^{1-\eta-\tau}h^{\eta}d^{\tau}\tau}{f_4\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right)}+\frac{dm_{1,d}(h,d)}{m_1(h,d)}.$$

So that $\frac{hu_{hc}(c,h,d)}{u_c(c,h,d)}$ and $\frac{du_{dc}(c,h,d)}{u_c(c,h,d)}$ only depend on $c^{1-\eta-\tau}h^{\eta}d^{\tau}$, it must be that $\frac{hm_{1,h}(h,d)}{m_1(h,d)}$ and $\frac{dm_{1,d}(h,d)}{m_1(h,d)}$ are constants and therefore $m_1(h,d)=A_2h^{\kappa}d^{\iota}$. We can rewrite (30) as

$$u_c(c,h,d)=f_4\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right)A_2h^{\kappa}d^{\iota}. \tag{31}$$

Since $1-\eta-\tau\neq 0$ we can rewrite that equation as

$$u_c(c,h,d)=f_5\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)A_2h^{\kappa}d^{\iota}.$$

We can integrate this equation with respect to c to find

$$u(c,h,d) = f_6\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)h^{\kappa-\frac{\eta}{1-\eta-\tau}}d^{\iota-\frac{\tau}{1-\eta-\tau}} + m_2(h,d) \tag{32}$$

where f_6 is another arbitrary function.

To further restrict $m_2(h,d)$, we combine Lemma 1 together with (31) to find

$$u_h(c,h,d) = f_7\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)A_2h^{\kappa-1-\frac{\eta}{1-\eta-\tau}}d^{\iota-\frac{\tau}{1-\eta-\tau}} \tag{33}$$

and

$$u_d(c,h,d) = f_8\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)A_2h^{\kappa-\frac{\eta}{1-\eta-\tau}}d^{\iota-1-\frac{\tau}{1-\eta-\tau}} \tag{34}$$

where f_7 and f_8 are appropriately defined functions.

We can now compare the derivatives of u, from (32), to these last two expressions. First, taking the derivative of (32) with respect to h we find

$$\begin{aligned}
u_h(c,h,d) &= f_9\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)h^{\kappa-\frac{\eta}{1-\eta-\tau}-1}d^{\iota-\frac{\tau}{1-\eta-\tau}}\frac{\eta}{1-\eta-\tau} \\
&\quad + f_6\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)h^{\kappa-\frac{\eta}{1-\eta-\tau}-1}d^{\iota-\frac{\tau}{1-\eta-\tau}}\left(\kappa-\frac{\eta}{1-\eta-\tau}\right) + m_{2,1}(h,d) \\
&= f_{10}\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)h^{\kappa-\frac{\eta}{1-\eta-\tau}-1}d^{\iota-\frac{\tau}{1-\eta-\tau}} + m_{2,1}(h,d)
\end{aligned}$$

For this to work with (33) for all c, h and d, it must be that $m_{2,1}(h,d) = A_3h^{\kappa-\frac{\eta}{1-\eta-\tau}-1}d^{\iota-\frac{\tau}{1-\eta-\tau}}$. Similarly, taking the derivative of (32) with respect to d we find

$$u_d(c,h,d) = f_{11}\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)h^{\kappa-\frac{\eta}{1-\eta-\tau}}d^{\iota-\frac{\tau}{1-\eta-\tau}-1} + m_{2,2}(h,d)$$

For this to work with (34), it must be that $m_{2,2}(h,d) = A_4h^{\kappa-\frac{\eta}{1-\eta-\tau}}d^{\iota-\frac{\tau}{1-\eta-\tau}-1}$.

We can integrate $m_{2,1}$ and $m_{2,2}$ to find m. Let us first handle the case with $\kappa \neq \frac{\eta}{1-\eta-\tau}$ and $\iota \neq \frac{\tau}{1-\eta-\tau}$. Integrating, we find

$$\begin{aligned}
m_2(h,d) &= A_5h^{\kappa-\frac{\eta}{1-\eta-\tau}}d^{\iota-\frac{\tau}{1-\eta-\tau}} + g_3(d) \\
m_2(h,d) &= A_6h^{\kappa-\frac{\eta}{1-\eta-\tau}}d^{\iota-\frac{\tau}{1-\eta-\tau}} + g_4(h)
\end{aligned} \tag{35}$$

For these two equations to be jointly true it must be that $A_5 = A_6$, and that g_3 and g_4 are the same constant. That constant can be set arbitrarily as it does not affect choices. In this case, we can merge m_2 in (32) and find

$$u(c,h,d) = f_{12}\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)h^{\kappa-\frac{\eta}{1-\eta-\tau}}d^{\iota-\frac{\tau}{1-\eta-\tau}} + A_7. \tag{36}$$

Since $\eta \neq 0$, we can write

$$u\left(c,h,d\right)=f_{13}\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)c^{1-\kappa\frac{1-\eta-\tau}{\eta}}d^{\iota-\frac{\tau}{\eta}\kappa}+A_{7}.$$

which is equivalent to

$$u\left(c,h,d\right)=\frac{\left(c^{1-\varepsilon}d^{\varepsilon}v\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right)\right)^{1-\sigma}-1}{1-\sigma} \tag{37}$$

where

$$\left(1-\sigma\right)\left(1-\varepsilon\right)=1-\kappa\frac{1-\eta-\tau}{\eta}$$
$$\left(1-\sigma\right)\varepsilon=\iota-\frac{\tau}{\eta}\kappa$$

If instead $\kappa=\frac{\eta}{1-\eta-\tau}$, integrating $m_{2,1}\left(h,d\right)=A_{3}h^{\kappa-\frac{\eta}{1-\eta-\tau}-1}d^{\iota-\frac{\tau}{1-\eta-\tau}}$ yields

$$m_{2}\left(h,d\right)=A_{5}d^{\iota-\frac{\tau}{1-\eta-\tau}}\log h+g_{3}\left(d\right), \tag{38}$$

and if $\iota=\frac{\tau}{1-\eta-\tau}$, integrating $m_{2,2}\left(h,d\right)=A_{4}h^{\kappa-\frac{\eta}{1-\eta-\tau}}d^{\iota-\frac{\tau}{1-\eta-\tau}-1}$ yields

$$m_{2}\left(h,d\right)=A_{6}h^{\kappa-\frac{\eta}{1-\eta-\tau}}\log d+g_{4}\left(h\right). \tag{39}$$

If only one of $\kappa=\frac{\eta}{1-\eta-\tau}$ or $\iota=\frac{\tau}{1-\eta-\tau}$ is true, it must be that $m_{2}=A_{7}$, where A_{7} is a constant. Suppose that only $\kappa=\frac{\eta}{1-\eta-\tau}$, (32) becomes

$$u\left(c,h,d\right)=f_{6}\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)d^{\iota-\frac{\tau}{1-\eta-\tau}}+A_{7}$$

so we find (37) with

$$\varepsilon=1$$
$$1-\sigma=\iota-\frac{\tau}{1-\eta-\tau}.$$

If only $\iota=\frac{\tau}{1-\eta-\tau}$, (32) becomes

$$u\left(c,h,d\right)=f_{6}\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)h^{\kappa-\frac{\eta}{1-\eta-\tau}}+m_{2}\left(h,d\right)$$

which we can rewrite as

$$u\left(c,h,d\right)=f_{14}\left(ch^{\frac{\eta}{1-\eta-\tau}}d^{\frac{\tau}{1-\eta-\tau}}\right)c^{1-\kappa\frac{1-\eta-\tau}{\eta}}d^{\frac{\tau}{1-\eta-\tau}-\frac{\tau}{\eta}\kappa}+m_{2}\left(h,d\right)$$

so we find (37) with

$$(1-\sigma)(1-\varepsilon) = 1-\kappa\frac{1-\eta-\tau}{\eta}$$
$$(1-\sigma)\varepsilon = \frac{\tau}{1-\eta-\tau} - \frac{\tau}{\eta}\kappa$$

If both $\kappa = \frac{\eta}{1-\eta-\tau}$ and $\iota = \frac{\tau}{1-\eta-\tau}$ it must be, from (38) and (39), that

$$m_2(h,d) = A_8 \log h + A_9 \log d + A_7,$$

in which case we can write (32) as

$$u(c,h,d) = f_6\left(ch^{\frac{\eta}{1-\eta-\tau}} d^{\frac{\tau}{1-\eta-\tau}}\right) + A_8 \log h + A_9 \log d + A_7.$$

We can use

$$\log\left(ch^{\frac{\eta}{1-\eta-\tau}} d^{\frac{\tau}{1-\eta-\tau}}\right) = \log c + \frac{\eta}{1-\eta-\tau}\log h + \frac{\tau}{1-\eta-\tau}\log d,$$

to write

$$u(c,h,d) = f_{15}\left(ch^{\frac{\eta}{1-\eta-\tau}} d^{\frac{\tau}{1-\eta-\tau}}\right) + A_8\frac{1-\eta-\tau}{\eta}\log c + \left(A_9 - A_8\frac{\tau}{\eta}\right)\log d + A_7.$$

Since the utility function is invariant to multiplication by a constant we can normalize the sum of the powers on c and d to 1, and get

$$u(c,h,d) = (1-\varepsilon)\log c + \varepsilon \log d + \log v\left(c^{1-\eta-\tau}h^{\eta}d^{\tau}\right). \tag{40}$$

We now turn to the case in which $1-\eta-\tau = 0$.

We now turn to the case with $1-\eta-\tau=0$. The characterization of u_{cc} in Lemma 2 can be written as

$$\frac{\partial \log(u_c(c,h,d))}{\partial \log(c)} = -z_1(h^{\eta}d^{\tau}).$$

Integrating with respect to $\log c$ we find that

$$\log(u_c(c,h,d)) = -\log(c)\, z(h^{\eta}d^{\tau}) + m_3(h,d) \tag{41}$$

where m_3 is an arbitrary function of h and d. Differentiating with respect to h and multiplying by h yields

$$\frac{hu_{ch}(c,h,d)}{u_c(c,h,d)} = -\log(c)\, z'(h^{\eta}d^{\tau})\,\eta h^{\eta} + hm_{3,1}(h,d). \tag{42}$$

Similarly, differentiating with respect to d and multiplying by d yields

$$\frac{du_{cd}(c,h,d)}{u_c(c,h,d)} = -\log(c)\, z'(h^\eta d^\tau)\, \tau d^\tau + d m_{3,2}(h,d). \tag{43}$$

From Lemma 2 we know that $\frac{hu_{hc}(c,h,d)}{u_c(c,h,d)}$ and $\frac{du_{dc}(c,h,d)}{u_c(c,h,d)}$ are only functions of $h^\eta d^\tau$. For (42) and (43) to hold true for every c it must therefore be that $z'(h^\eta d^\tau) = 0$ (note that a and b cannot both be equal to 0 since $1-\eta-\tau = 0$) so that $z = -\sigma$ is a constant. Similarly, it must be that $hm_{3,1}(h,d) = g_5(h^\eta d^\tau)$ and $dm_{3,2}(h,d) = g_6(h^\eta d^\tau)$. Integrating, we find that $m_3(h,d) = f_{16}(h^\eta d^\tau)$ for some function f_{16}. By exponentiating on both sides of (41), we can therefore rewrite

$$u_c(c,h,d) = c^{-\sigma} m_4(h^\eta d^\tau). \tag{44}$$

We can integrate this equation with respect to c to find

$$u(c,h,d) = \frac{(cv(h^\eta d^\tau))^{1-\sigma} - 1}{1-\sigma} + m_5(h,d) \tag{45}$$

if $\sigma \neq 1$, or

$$u(c,h,d) = m_4(h^\eta d^\tau)\log(c) + \log(v(h^\eta d^\tau)) \tag{46}$$

otherwise.

For the case with $\sigma \neq 1$, combine (44) with Lemma 1 that

$$u_h(c,h,d) = \frac{1}{h} x(h^\eta d^\tau)\, c^{1-\sigma} m_4(h^\eta d^\tau)$$

and

$$u_d(c,h,d) = \frac{1}{d} y(h^\eta d^\tau)\, c^{1-\sigma} m_4(h^\eta d^\tau).$$

Differentiating (45) yields

$$u_h(c,h,d) = (cv(h^\eta d^\tau))^{-\sigma}\, cv'(h^\eta d^\tau)\, a\frac{h^\eta d^\tau}{h} + m_{5,1}(h,d)$$

and

$$u_d(c,h,d) = (cv(h^\eta d^\tau))^{-\sigma}\, cv'(h^\eta d^\tau)\, b\frac{h^\eta d^\tau}{d} + m_{5,2}(h,d).$$

Since $\sigma \neq 1$ it must be that m_5 is a constant that can be set to 0 as it does not affect decisions. (45) is therefore a special case of (37).

For the case with $\sigma = 1$, we can again combine (44) with Lemma 1 to find the two equations

$$\begin{aligned} u_h(c,h,d) &= \frac{1}{h} x\left(h^\eta d^\tau\right) m_4\left(h^\eta d^\tau\right) \\ u_d(c,h,d) &= \frac{1}{d} y\left(h^\eta d^\tau\right) m_4\left(h^\eta d^\tau\right). \end{aligned}$$

Differentiating (46) yields

$$\begin{aligned} u_h(c,h,d) &= m_4'\left(h^\eta d^\tau\right) a \frac{h^\eta d^\tau}{h} \log(c) + \frac{v'\left(h^\eta d^\tau\right)}{v\left(h^\eta d^\tau\right)} a \frac{h^\eta d^\tau}{h} \\ u_d(c,h,d) &= m_4'\left(h^\eta d^\tau\right) b \frac{h^\eta d^\tau}{d} \log(c) + \frac{v'\left(h^\eta d^\tau\right)}{v\left(h^\eta d^\tau\right)} b \frac{h^\eta d^\tau}{d}. \end{aligned}$$

For these equations to be consistent it must be that m_4 is a constant so we find (40) again.

This completes the proofs that if u satisfies Definition 1 then it must be of the form (13)–(14). We now show that if u is defined as (13)–(14) then Definition 1 is also satisfied.

First notice that if we evaluate the function $c^{1-\eta-\tau} h^\eta d^\tau$ along a balanced-growth path, i.e. at a point $\left(c_0\left(\gamma_w^\eta \gamma_{pd}^\tau\right)^t, h_0\left(\gamma_w^{\eta-1}\gamma_{pd}^\tau\right)^t, d_0\left(\gamma_w^\eta \gamma_{pd}^{\tau-1}\right)^t\right)$, we get

$$\left(c_0\left(\gamma_w^\eta \gamma_{pd}^\tau\right)^t\right)^{1-\eta-\tau}\left(h_0\left(\gamma_w^{\eta-1}\gamma_{pd}^\tau\right)^t\right)^\eta\left(d_0\left(\gamma_w^\eta\gamma_{pd}^{\tau-1}\right)^t\right)^\tau = c_0^{1-\eta-\tau} h_0^\eta d_0^\tau.$$

In other words, $c^{1-\eta-\tau} h^\eta d^\tau$ is invariant along a balanced-growth path.

The derivatives of u are

$$\begin{aligned} u_h &= \left(c^{1-\varepsilon} d^\varepsilon v\left(c^{1-\eta-\tau} h^\eta d^\tau\right)\right)^{-\sigma} c^{1-\varepsilon} d^\varepsilon v'\left(c^{1-\eta-\tau} h^\eta d^\tau\right) \eta \frac{c^{1-\eta-\tau} h^\eta d^\tau}{h} \\ u_d &= \left(c^{1-\varepsilon} d^\varepsilon v\left(c^{1-\eta-\tau} h^\eta d^\tau\right)\right)^{-\sigma}\left(\varepsilon \frac{c^{1-\varepsilon} d^\varepsilon}{d} v\left(c^{1-\eta-\tau} h^\eta d^\tau\right) + c^{1-\varepsilon} d^\varepsilon v'\left(c^{1-\eta-\tau} h^\eta d^\tau\right) \tau \frac{c^{1-\eta-\tau} h^\eta d^\tau}{d}\right) \\ u_c &= \left(c^{1-\varepsilon} d^\varepsilon v\left(c^{1-\eta-\tau} h^\eta d^\tau\right)\right)^{-\sigma} \times \\ &\quad \left((1-\varepsilon) \frac{c^{1-\varepsilon} d^\varepsilon}{c} v\left(c^{1-\eta-\tau} h^\eta d^\tau\right) + c^{1-\varepsilon} d^\varepsilon v'\left(c^{1-\eta-\tau} h^\eta d^\tau\right)(1-\eta-\tau) \frac{c^{1-\eta-\tau} h^\eta d^\tau}{c}\right) \end{aligned}$$

Taking the ratio of u_h and u_c and evaluating the expression at a point on a balanced-growth path, $\left(c_0\left(\gamma_w^\eta \gamma_{pd}^\tau\right)^t, h_0\left(\gamma_w^{\eta-1}\gamma_{pd}^\tau\right)^t, d_0\left(\gamma_w^\eta \gamma_{pd}^{\tau-1}\right)^t\right)$, we find that

$$\frac{u_h}{u_c} = \frac{v'\left(c_0^{1-\eta-\tau} h_0^\eta d_0^\tau\right) \eta c_0^{1-\eta-\tau} h_0^\eta d_0^\tau}{(1-\varepsilon) v\left(c_0^{1-\eta-\tau} h_0^\eta d_0^\tau\right) + v'\left(c_0^{1-\eta-\tau} h_0^\eta d_0^\tau\right)(1-\eta-\tau) c_0^{1-\eta-\tau} h_0^\eta d_0^\tau} \frac{c_0}{h_0} \gamma_w^t$$

so that u_h/u_c grows at rate γ_w and so (10) is satisfied.[44]

Similarly, taking the ratio of u_d and u_c and evaluating the expression at $\left(c_0\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right)^t, h_0\left(\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\right)^t, d_0\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)^t\right)$ we find

$$\frac{u_d}{u_c} = \frac{\left(\varepsilon v\left(c_0^{1-\eta-\tau}h_0^{\eta}d_0^{\tau}\right) + v'\left(c_0^{1-\eta-\tau}h_0^{\eta}d_0^{\tau}\right)\tau c_0^{1-\eta-\tau}h_0^{\eta}d_0^{\tau}\right)}{\left((1-\varepsilon)v\left(c_0^{1-\eta-\tau}h_0^{\eta}d_0^{\tau}\right) + v'\left(c_0^{1-\eta-\tau}h_0^{\eta}d_0^{\tau}\right)(1-\eta-\tau)c_0^{1-\eta-\tau}h_0^{\eta}d_0^{\tau}\right)}\frac{c_0}{d_0}\gamma_{p_d}^{t}$$

so that u_d/u_c grows at rate γ_{p_d} and (11) is satisfied.

Finally, dividing u_c evaluated at $\left(c_0\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right)^t, h_0\left(\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\right)^t, d_0\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)^t\right)$ by u_c evaluated at $\left(c_0\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau}\right)^{t+1}, h_0\left(\gamma_w^{\eta-1}\gamma_{p_d}^{\tau}\right)^{t+1}, d_0\left(\gamma_w^{\eta}\gamma_{p_d}^{\tau-1}\right)^{t+1}\right)$ we find

$$\frac{u_c}{u_c'} = \gamma_w^{\eta\sigma}\gamma_{p_d}^{\tau-(1-\sigma)(\tau-\varepsilon)}$$

which is an expression independent of c, d and h, as required by 12, and that defines r. □

Proposition 2. *On a balanced-growth path, the growth rates of p_{dt} and w_t are*

$$\begin{aligned}\log\gamma_{p_d} &= \log\gamma_{A_c} - \log\gamma_{A_d},\\ \log\gamma_w &= \alpha\log\gamma_{A_c}.\end{aligned} \tag{19}$$

Proof. The first-order conditions of the firms are

$$\alpha p_{jt}y_{jt} = w_t l_{jt} \tag{47}$$

and

$$(1-\alpha)\,p_{jt}y_{jt} = R_t k_{jt} \tag{48}$$

so that

$$\frac{\alpha}{1-\alpha}R_t\left(k_{ct}+k_{dt}\right) = w_t\left(l_{ct}+l_{dt}\right) \tag{49}$$

and

$$\frac{l_{ct}}{k_{ct}} = \frac{l_{dt}}{k_{dt}} = \frac{l_{ct}+l_{dt}}{k_{ct}+k_{dt}}.$$

Combining (48) for $j = c$ with $p_{it}A = R_t$, the production function (18) and using the fact that $p_{ct} = 1$ yields the price of investment

$$p_{it} = (1-\alpha)\frac{A_{ct}}{A}\left(\frac{l_{ct}+l_{dt}}{k_{ct}+k_{dt}}\right)^{\alpha}. \tag{50}$$

[44] Note that by Definition 1 we can adjust h_0 to match the wage so that $-u_h/u_c$ matches the arbitrary wage w. This requires $v' \neq 0$, but if $v' = 0$ hours does not enter the utility function and the only possible wage is $w = 0$.

With $p_{it}A = R_t$, this equation also pins down the interest rate

$$R_t = (1-\alpha)\, A_{ct} \left(\frac{l_{ct} + l_{dt}}{k_{ct} + k_{dt}} \right)^{\alpha}. \tag{51}$$

Doing the same operations with $j = d$ instead, and combining with (50) we find that the price of recreation goods and services, measured in units of non-recreation prices, is the ratio of sector c and sector d productivities:

$$p_{dt} = \frac{A_{ct}}{A_{dt}}.$$

It follows that the growth rate γ_{p_d} of p_{dt} is such that $\log \gamma_{p_d} = \log \gamma_{A_c} - \log \gamma_{A_d}$.

Combining (51) with (49) yields

$$R_t^{1-\alpha} = (1-\alpha)\, A_{ct} \left(\frac{\alpha}{1-\alpha} \frac{1}{w_t} \right)^{\alpha}.$$

Since the first-order conditions of the household imply a constant R_t, this last equation yields that

$$\log \gamma_w = \alpha \log \gamma_{A_c},$$

which completes the proof. □