Time Use and Macroeconomic Uncertainty (Preliminary and Incomplete)

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Abstract

We estimate the effects of aggregate uncertainty on time use and discuss its macroeconomic implications. Using data from the American Time Use Survey and the Current Population Survey, we infer monthly and quarterly cyclical variation in home production and leisure time. We then document that higher uncertainty increases housework and reduces market work hours, with modest effects on leisure. Finally, we propose a model of housework with time-varying uncertainty that quantitatively accounts for the empirical estimates. We use the model to study how time allocation affects households' precautionary behaviour and the aggregate transmission of uncertainty. We establish two new results. First, substitution between market and nonmarket work provides an additional insurance margin to households, dampening precautionary savings and labor supply. Second, although precautionary motives are weakened, time-use reallocation ultimately lowers aggregate demand, amplifying the contractionary effects of uncertainty. Overall, time substitution explains about one-fourth of the decline in aggregate output following an uncertainty shock. Policies that reallocate time use towards housework (e.g., lockdown policies) amplify the recessionary effects of uncertainty. Moreover, while higher uncertainty acts as a negative demand shock, time-use reallocation can result in aggregate dynamics consistent with a supply-side shock.

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1 Introduction

In the past fifteen years, a vast literature has dissected virtually every aspect of the aggregate effects of uncertainty, both theoretically and empirically. A central message of this research is that households' behaviour is key to macroeconomic transmission (e.g., Basu and Bundick, 2017). First, when uncertainty increases, individuals increase savings and reduce consumption and aggregate demand (precautionary savings). Second, individuals increase labor supply (precautionary labor supply).[1]

Yet, some questions remain unaddressed. How does macroeconomic uncertainty affect time allocation between market work, housework, and leisure? Does time reallocation provide an additional insurance margin against future macroeconomic shocks? Answering these questions is important because individuals' ability to reallocate time to housework may affect precautionary motives. Moreover, time reallocation affects the dynamics of market-goods expenditures, begging the question of whether time-use variation ultimately mitigates or amplifies the impact of uncertainty on aggregate activity and welfare. Finally, understanding how time allocation varies with uncertainty can shed new light on the economic developments that followed the outbreak of the COVID-19 pandemic. This unprecedented event in modern history has been characterized by a large spike in uncertainty accompanied by the introduction of economy-wide policies that forced households to reallocate time use and expenditures (e.g., lockdown policies).

In the first part of the paper, we use data from the American Time Use Survey (ATUS) and the Current Population Survey (CPS) to infer quarterly cyclical variation in home production and leisure time. Our approach overcomes data limitations that, thus far, prevented a systematic analysis of the relationship between time use and uncertainty. Specifically, aggregate data on home production are available for a long period only at a very low frequency. Moreover, while the ATUS records time use at business cycle frequency since 2003, nonmarket work and leisure series display well-documented secular trends that started in the 1960s (e.g., Aguiar and Hurst, 2016). In turn, the relatively short sample prevents the application of standard detrending methods.

We overcome data limitations by constructing measures of cyclical variation in nonmarket work and leisure. Our approach combines insights from the very influential work of Aguiar, Hurst, and

[1] These predictions obtain in a large class of models, spanning benchmark neoclassical growth models with representative agents all the way to models featuring agents heterogeneity.

Karabarbounis (2013)—AHK henceforth—and Mukoyama, Patterson, and Şahin (2018). Building on AHK, we exploit cross-state variation in time use to estimate how market hours are reallocated to other time uses (e.g., home production, leisure, etc.) for cyclical reasons—what we label cyclical substitution rates. We show that such reallocation is acyclical and does not depend on the state of the business cycle or on the degree of economic uncertainty. We then use the estimated substitution rates to infer time series for home production and leisure using CPS data, obtaining a sample that spans the years 1994-2019. In this regard, our approach is conceptually similar to Mukoyama, Patterson, and Şahin (2018), who combine information from the ATUS and the CPS to construct a measure of search effort.

Using these novel time series, we estimate local projections to identify the response of market hours, housework, and leisure following an increase in uncertainty. Following the standard practice in the literature, our benchmark measure of aggregate uncertainty is the monthly Chicago Board Options Exchange Volatility Index (VXO), which measures the expected volatility of the Standard and Poor's 100 stock index over the next 30 days. Following the literature, we impose contemporaneous restrictions to identify variation in uncertainty that is plausibly exogenous to first-moment shocks. The local projection estimates imply that higher uncertainty increases housework and reduces market work hours, with modest effects on leisure.

Next, we propose a model of housework with time-varying uncertainty that quantitatively accounts for the empirical estimates. As argued by Becker (1965), consumption is the final stage of production, which takes place at the household level and combines time with expenditure on market goods. Following the seminal work of Benhabib, Rogerson, and Wright (1991a), we assume that households can employ time (and, in an extension of the model, capital) to produce a good that is non-tradable on the market. In addition to home production, households also enjoy consumption of market goods and leisure. We embed this benchmark housework structure in an otherwise-standard dynamic stochastic general equilibrium model that features both first- and second-moment shocks. Aside from the presence of home production, the model follows Basu and Bundick (2017), including sticky prices, endogenous capital accumulation, and shocks to preference and technology. Together with Born and Pfeifer (2014) and Fernandez-Villaverde, Guerron-Quintana, Kuester, and Rubio-Ramirez (2015), this work provides the workhorse framework for studying the aggregate transmission of uncertainty. Our model is able to accurately account for the data obtained using a standard and empirically-plausible parametrization of the substitutability between market and nonmarket consumption goods without targeting any of the responses estimated in the data.

We use the model to study how time use allocation affects households' precautionary behavior and the aggregate transmission of uncertainty. We establish two main new results. First, time reallocation provides an additional insurance margin to households, dampening precautionary savings and labor supply. Second, although precautionary motives are weakened, time reallocation lowers aggregate demand, amplifying the contractionary effects of uncertainty. Our benchmark parameterization implies that time reallocation towards housework explains about one-fourth of the decline in aggregate output following a one-standard-deviation increase in uncertainty.

The intuition for these results is the following. A simple two-period, partial-equilibrium version of the model—ultimately corresponding to the saving model studied by Ljungqvist and Sargent (2004) (pag. 599) augmented with home production—illustrates how time reallocation affects precautionary motives. Since consumption and leisure are normal goods, when uncertainty increases, households prefer to reduce the consumption of all goods out of precaution and work more to build a buffer against higher future expected volatility in market consumption. Holding relative prices constant, the additional substitution margin brought about by housework dampens the fall in market consumption and the rise in market hours that follow a spike in uncertainty. Responses are milder relative to a model without home production and become milder as the substitutability between home and market goods increases. Effectively, time reallocation provides self-insurance, mitigating, for given prices, the impact of uncertainty on the equilibrium allocation. Studying Frisch functions for hours worked, housework, total consumption and market consumption, we also show that market hours become more elastic in the presence of housework. The reason is that, as the real wage (and thus labor income) falls, the household can compensate the shortfall in market expenditure by increasing housework and consuming more home goods. Such substitution contributes to stabilizing fluctuations in total consumption. In turn, it is this substitution that makes housework an effective self-insurance tool when shocks to labor income materialize.

As time reallocation mitigates precautionary motives and weakens intertemporal substitution, one may expect that it also dampens the contractionary effects of uncertainty. However, time reallocation also induces complementarity between market-hours worked and consumption expenditures on market goods. That is, a given income decline results in an intratemporal substitution of market expenditures with home goods that would not be feasible in the absence of home production. The higher aggregate demand elasticity to uncertainty ultimately explains the more severe recession.

In the last part of the paper, we use the model to shed new light on macroeconomic dynamics following the COVID-19 pandemic. The onset of the pandemic induced a sharp increase in uncertainty and led to the adoption of policies that resulted in a significant shift in how people spend their time.[2] The shutting down of contact-intensive sectors and the subsequent lockdowns forced households to cut expenditures on market-produced goods and employment-related activities while increasing housework. We demonstrate that policies that induce such a reallocation—captured, in reduced form, by an exogenous decrease in the expenditure share on market-goods consumption—compound the adverse effects on aggregate demand brought about by time-use variation at times of heightened uncertainty. Moreover, while higher uncertainty acts as a negative demand shock for a given time allocation, substitution from market to nonmarket hours stemming from higher future expected volatility and government policy can result in dynamics consistent with a supply-side shock. Holding constant monetary and fiscal policy, a heuristic calculation shows that higher uncertainty in the absence of any substitution towards housework would have lowered output and inflation by, respectively, 2% and 0.75% at the onset of the pandmic. Time-use reallocation doubled the output decline, but reduced the inflation decline. An important caveat when interpreting these results is that our model and analysis abstract from the beneficial effects on output and welfare of policies that limit contagion during a pandemic.

Related Literature We contribute to two main strands of the literature. First, our paper relates to the burgeoning literature analyzing the aggregate effects of uncertainty, providing new insights about the role of households behaviour.[3]. As home production is absent in these studies, our contribution is to highlight the impact of time use—market work, nonmarket work and leisure time—on precautionary labor supply and savings, which are central for the propagation of uncertainty. Moreover, we also show that empirically-disciplined complementarity between market hours worked and consumption expenditures is a quantitatively important margin of uncertainty propagation, a novel result in the literature. This finding also relates to several studies where such a complementarity is hardwired into preferences to explain a range of different macroeconomic outcomes (e.g., Nakamura and Steinsson (2014), Christiano, Eichenbaum, and Rebelo (2011), Bilbiie (2011), Monacelli and Perotti (2010), Hall (2009)).

Second, this paper is related to the literature studying home production and its macroeconomic implications. Benhabib, Rogerson, and Wright (1991a) and Greenwood and Hercowitz (1991) emphasized the importance of accounting for households' time allocation to explain a number of

[2] Castelnuovo (2022) provides an excellent survey of the literature on the macroeconomic effects of uncertainty before and during COVID-19.

[3] For an excellent review of the literature on uncertainty shocks and business cycle research see Fernandez-Villaverde and Guerron-Quintana, 2020.

macroeconomic facts. For example, substitution between market hours worked and housework improves the explanatory power of fluctuations in total factor productivity for understanding cyclical variation in output and investment, of which a significant component is households' capital. These seminal contributions spurred further research. McGrattan, Rogerson, and Wright (1997) estimate the model in Benhabib, Rogerson, and Wright (1991a) to analyze the role of home production in shaping the households' response to tax changes, (Aruoba, Davis, and Wright (2016)) document how interest rates and inflation affect households' incentives to reallocate labor and capital between market and home activities, and Gnocchi, Hauser, and Pappa (2016a) show the importance of home production in accounting for the magnitude of fiscal multipliers. In the context of an open-economy model, (Karabarbounis (2014)) show how the feedback between the home and market sectors can help explaining several stylized facts studied by international macroeconomics. Parallel and as a complement to those contributions, a series of papers focused on documenting a number of facts related to time allocation, from its secular trends (see e.g., Aguiar and Hurst (2016), Ramey and Francis (2009), Ramey (2009)) to the reallocation of lost market hours during the great recession (Aguiar, Hurst, and Karabarbounis (2013)), or during the pandemic-induced recession (Leukhina and Yu (2022a)). Our contribution to this literature is twofold. On the one hand, we construct measures of cyclical variation in housework and leisure and document hitherto unexplored role of uncertainty for time use. On the other hand, we show how households' time use decisions affect the transmission of uncertainty to market variables.

2 Time Use and Uncertainty in the Data

This section studies how time use responds to increased uncertainty. Thus far, the dearth of comprehensive data have prevented a systematic analysis of this issue. An important limitation is that aggregate data on time use are available for a long period only at a very low frequency. Since the early 2000s, an alternative source is the ATUS database, a time-use survey that measures the amount of time people spend on various activities, including work, leisure, and household activities. ATUS data provide time-use information at business cycle frequency. However, the relatively short sample of the data combined with the well-documented secular trends in aggregate nonmarket work time and leisure still preclude ordinary time series analysis. The short sample prevents the application of standard detrending methods, as already pointed out by AHK. Moreover, to identify the effects of uncertainty on time use, researchers can only exploit cross-sectional variation in uncertainty exposure, which by design rules out general-equilibrium effects.

The first contribution of our paper is to construct measures of cyclical variation in nonmarket work and leisure. Our approach uses ATUS and CPS data, combining insights from AHK and Mukoyama, Patterson, and Şahin (2018). Our approach can be summarized as follows. Start by noticing that the cyclical variation in aggregate market hours allocated to activity j can be expressed as:

$$\Delta H_t^j = \beta_t^j \Delta H_t^{market}, \tag{1}$$

where ΔH_t^{market} denotes the change in aggregate market hours, and β_t^j represents the fraction of market hours reallocated to activity j for cyclical reasons at time t. Equation (1) generalizes the decomposition in AHK by allowing for a potentially time-varying β^j. Below we refer to β_t^j as the cyclical substitution rate of activity j. However, equation (1) only provides a statistical decomposition, implying that β_t^j represents an accounting device, and not a structural parameter that captures households' preferences.

We estimate the cyclical substitution between market work and other time-use categories by extending the methodology proposed by AHK. Next, we use the estimated substitution rates to infer cyclical variation in housework and leisure using (1). Finally, we estimate local projections to identify the effects of uncertainty on market hours, housework, and leisure.

Cyclical Variation in Time Use

We use data from the 2003–2019 waves of the ATUS. The ATUS is conducted by the Bureau of Labor Statistics and individuals in the sample are drawn from the exiting sample of the CPS.[4] We further complement our analysis with data from the American Heritage Time Use Study (AHTUS) for the years 1993, 1995, and 1998. Following AHK we segment the allocation of time into broad time use categories that are mutually exclusive and that sum to the individual's entire time endowment. We restrict the sample to working-age respondents (between age 15-65), and focus on three primary time use categories: Market work, nonmarket work, and leisure. Market work includes all time spent working in the market sector, including commuting to and from work, and time spent on work-related activities.[5] Nonmarket work includes core home production (e.g., cooking, cleaning, or doing laundry), activities related to home ownership (such as household repairs and gardening), obtaining goods and services (including grocery shopping, going to the bank, and online shopping),

[4] ATUS data is a pooled cross section, as each respondent is interviewed once.

[5] Time spent on job search and on other income-generating activities outside the formal sector, are not included in market work.

and care of other adults (e.g., preparing meals and shopping for other adults, and transporting other adults to doctors offices). Finally, leisure includes time spent watching TV, socializing, exercising, reading, sleeping, eating, time spent on sports, entertainment, hobbies and personal care.

There is ample evidence that nonmarket work has been declining over time, while leisure time has been increasing (see e.g., Aguiar and Hurst (2016), Ramey and Francis (2009), Ramey (2009)). Thus, as discussed by AHK, the relatively short time frame of the sample precludes the use of standard detrending methods. We follow AHK and exploit the variation of cross-state business cycles to remove these low-frequency trends in time use when estimating substitution rates. Hence, we construct average state-level time use across individual respondents (i.e., we treat the data as a pseudo panel), and we assume that there are no state-specific low-frequency trends in time use.

To infer how changes in market hours worked affect different time use categories, we consider three alternative state-level specifications. The first specification constrains β_t^j to be constant across time, following AHK. The second specification relaxes this assumption and allows for time variation in β_t^j. The third specification addresses whether β_t^j differs at times of high and low uncertainty. Across these exercises, the main finding is that the substitution rate between market hours and housework or leisure is stable over time and across regimes of low and high uncertainty.

Constant Substitution

Our first specification re-estimates the main regression in AHK using ATUS data from 2003–2019:

$$\Delta\tau_{s,t}^j = \alpha^j - \beta^j \Delta\tau_{s,t}^{market} + \gamma\Delta X_{s,t} + \varepsilon_{s,t}^j, \tag{2}$$

where $\Delta\tau_{st}^j$ is the change in hours per week spent on time use category j for the average individual in state s between period $t-1$ and t. $\Delta\tau_{st}^{market}$ is the change in market hours worked for the average individual in state s between period $t-1$ and t. $\Delta X_{s,t}$ are demographic controls, to capture potentially time-varying state-level demographic composition (e.g., due to interstate migration, or sampling variation).[6] The coefficient of interest, β^j, measures the fraction of foregone market hours allocated to time-use category j. β^j is a simple accounting device that measures how activity j co-varies with market hours once aggregate trends (captured by the constant α^j) are controlled for. For brevity, below we refer to the β^j's as reduced-form substitution rates, while it remains

[6] We include the same controls as AHK, i.e., the sample fraction of five age bins (18-27, 28-37, 38-47, 48-57, 58-65), four education bins (less than high school, high school, some college, BA/MA/PhD), the sample fraction that is male, black, married, and has at least one child.

Time Use Category	$\hat{\beta}^j$ (1)	$\hat{\beta}^j_L$ (3)	$\hat{\beta}^j_H$ (3)	p-value $H_0: \hat{\beta}^j_L = \hat{\beta}^j_H$
Nonmarket Work	0.25	0.22	0.25	0.24
Leisure	0.60	0.60	0.61	0.83

Table 1: Estimated cyclical substitution between market work and nonmarket work or leisure, from regression (1) and (3).

understood that such parameters bear no structural interpretation. We estimate equation (2) using weighted least squares, where states are weighted by their population.

The estimates in AHK—based on ATUS data from 2003–2010—remain largely unchanged when using nine additional years of ATUS data. Table 2 reports the estimated β^j for nonmarket work and leisure, when $\Delta\tau^j_{st}$ is defined as the difference in average time spent on activity j in state s from one non-overlapping two-year period to another.[7] A reduction of one hour per week in market work increases time spent on nonmarket work by 0.25 (vs. 0.28 in AHK), and time spent on leisure by 0.60 (vs. 0.52 in AHK). These estimates are robust to alternative definitions of the dependent variable, $\Delta\tau^j_{st}$, based on annual or quarterly state-level data, and when including state-level and/or time fixed effects (see Appendix A).

Time-Varying Substitution

It is conceivable that the allocation of foregone work hours to alternative time uses may have changed over time. To explore potential time-variation, we use a repeated cross-section that combines the available ATUS data from 2003–2019 with AHTUS data for the years 1993, 1995, and 1998 to estimate the following regression for each year t:

$$\Delta\tau^j_{s,t} = \alpha^j_t - \beta^j_t \times \Delta\tau^{market}_{s,t} + \gamma_t \Delta X_{s,t} + \varepsilon_{s,t}, \quad (3)$$

where $\Delta\tau^j_{s,t}$ is now defined as the year-over-year change in time use of activity j in state s.[8] We then test the null hypothesis $H_0 : \beta^j_t = \beta^j$, where β^j is the coefficient from equation (2) estimated over the entire sample. Table A in Appendix A reports the respective p-values. We do not find

[7] As the ATUS weighting procedure does not guarantee that the sample is representative of the population in a given state, AHK average state-level data over two years to mitigate measurement error due to sampling variation. AHK use 2003–2010 ATUS data and thus have a total of 153 observations. Our estimation relies on 357 observations (51 states, 7 differences over two-year periods).

[8] AHTUS data is available for other years, but unfortunately only includes information on respondents' state of residence in 1993, 1995, and 1998. To estimate the substitution rate for 1995, the dependent variable is defined as $\Delta\tau^j_{s,95} = \tau^j_{s,1995} - \tau^j_{s,1993}$, and for 1998, we have $\Delta\tau^j_{s,98} = \tau^j_{s,1998} - \tau^j_{s,1995}$.

any statically significant difference (at the 95% level) between β_t^j and β^j for any activity j (with the exception of leisure in the years 2009 and 2015). Thus, the data suggest that the estimated substitution rates are stable over time.

State-Dependence

Finally, we consider also the possibility that individuals who experience a reduction in work hours during times of heightened uncertainty, may choose to allocate their time to different activities than they would in normal times. We therefore explore potential state-dependence of the substitution rates, an important issue given our interest in the effects of uncertainty on time use. In this case, we estimate the following version of (2)

$$\Delta\tau_{s,t}^{j} = \alpha^j - \left[\beta_L^j \left(1 - \mathcal{I}_t\right) + \beta_H^j \mathcal{I}_t\right] \times \Delta\tau_{s,t}^{market} + \gamma \Delta X_{s,t} + \varepsilon_{s,t}, \tag{4}$$

where $\mathcal{I}_t$ is a dummy variable taking value one in periods where the Chicago Board Options Exchange Volatility Index (VXO) is one standard deviation above the mean, and zero otherwise.[9]

The estimated coefficients of equation (4), reported in Table 2, further suggest that the substitution rates are stable across times of high vs. low uncertainty. The respective null hypothesis ($H_0 : \hat{\beta}_L^j = \hat{\beta}_H^j$) can be rejected (at the 95% level) for both nonmarket work and leisure. The data thus suggest that the estimated coefficients are stable across regimes of low and high uncertainty.

Time Series for Time Use

Given the time and state independence of the estimated substitution rates, our benchmark time-use series are constructed with β^j from (2) estimated over the entire ATUS data from 2003–2019. For robustness, we also construct alternative series based on annual estimates for β_t^j as per (3).

We compute the implied changes in hours of a given activity j, by combining the estimated substitution rates, β^j, with observed changes in market hours

$$\Delta H_t^j = \hat{\beta}^j \Delta H_t^{market}$$

where H_t^{market} are deseasonalized "actual hours worked at the main job last week" from 1994:Q1–

[9] Alternative, we use the state-level policy uncertainty index (available here) to construct a dummy variable that takes value 1 in quarters where this state-level uncertainty measure is one standard deviation above the mean, and zero otherwise. The estimated coefficients and p-values are almost identical to the ones reported in Table 2.

2019:Q4, taken from the CPS. We recover H_t^j using average time-use from ATUS as initial condition. The time-use series capture the cyclical variation in time use of activity j, up to measurement error.[10] Our exercise is similar in spirit to Mukoyama, Patterson, and Şahin (2018), who combine information from the ATUS and the CPS to construct a measure of search effort.

Response of Time Use to Uncertainty

We are finally ready to estimate the effects of uncertainty on time use. Following standard practice in the literature, our benchmark measure of uncertainty is the monthly VXO, which measures the expected volatility of the Standard and Poor's 100 stock index over the next 30 days.

We first identify variation in uncertainty plausibly exogenous to first-moment shocks, e.g., "uncertainty shocks". We then use the identified shocks to estimate local projections. Since Jordà (2005), local projections have become a popular and well-established tool to estimate impulse response functions in macroeconomics. The approach consists of running a sequence of predictive regressions of a variable of interest on a structural shock for different prediction horizons. Thus, local projections construct impulse responses as a direct multi-step forecasting regression, providing a flexible and parsimonious approach that does not impose (potentially inappropriate) dynamic restrictions.

Following standard practice in the literature (e.g., Bloom (2009), and subsequent studies), we identify uncertainty shocks by estimating a structural VAR that includes the VXO (vxo_t) the log-differences in industrial production (Δip_t), employed persons (Δn_t), the level of crude oil prices (oil_t), and the federal funds rate (ffr_t). We impose standard contemporaneous restrictions such that innovations to the VXO do not affect real economic activity within a month. Effectively, these restrictions imply that we can directly estimate:

$$vxo_t = \alpha + \sum_{i=1}^{p} \phi_i^{vxo} vxo_{t-i} + \sum_{i=0}^{p} \phi_i^{ip} \Delta ip_{t-i} + \sum_{i=0}^{p} \phi_i^{n} \Delta n_{t-i} + \sum_{i=0}^{p} \phi_i^{oil} oil_{t-i} + \sum_{i=0}^{p} \phi_i^{ffr} ffr_{t-i} + \mu_t^{vxo}. \quad (5)$$

We also estimate a quarterly version of equation (5), in this case replacing industrial production with real GDP. To document the conditional dynamics of time use after an uncertainty shock (μ_t^{vxo}),

[10] Appendix A confirms the finding in AHK that individuals adjust nonmarket and leisure hours when their market hours change. But individuals do not appear to adjust their time use systematically with changes in the aggregate state of the economy (holding their market hours constant). Hence, H_t^j does not capture cyclical substitution between leisure and nonmarket hours (for given ΔH_t^{market}).

we then estimate the following instrumental variable local projections (LP-IV):

$$\log H^j_{t+\kappa} - \log H^j_t = \delta_\kappa + \gamma_\kappa \widehat{vxo}_t + \sum_{i=1}^{p} \phi_{vxo} vxo_{t-i} + \sum_{i=1}^{p} \phi_{h^j} \log H^j_{t-i} + \varepsilon^j_t \tag{6}$$

for $\kappa = 0, 1, 2, ...$, where $\widehat{vxo}_t$ are the fitted values from regressing our instrument on the VXO.[11] We instrument the VXO with the identified shock $\hat{\mu}^{vxo}_t$—rather than projecting directly $\hat{\mu}^{vxo}_t$—to account for estimation uncertainty around the point estimate of $\hat{\mu}^{vxo}_t$.[12] We estimate (6) both at monthly and quarterly frequency.[13] Figures 2 and 2 plot the estimated dynamics of market hours, nonmarket hours and leisure time in response to a one-standard deviation uncertainty shock—increasing the VXO by 31%.[14] The uncertainty shock generates a contraction in market hours (with a peak response of roughly -0.15 percent). In contrast, both non-market hours worked and leisure increase. The increase in non-market hours worked is roughly three times as much as the increase in leisure time. This finding is consistent with the results in AHK that nonmarket work is three times a more elastic margin of substitution than leisure.[15] In Appendix A, we show these results are robust to considering two alternative measures of uncertainty constructed by Jurado, Ludvigson, and Ng (2015).

3 Risk and Precaution in a Model of Home Production

We augment a standard two-period partial-equilibrium savings problem as in Ljungqvist and Sargent (2004) (pag. 599) with home production modelled along the lines of Benhabib, Rogerson, and Wright (1991b), where the household self-produces home goods that can be consumed, but neither traded on the market nor stored. The partial equilibrium analysis better highlights the role of housework in shaping the transmission of uncertainty to market variables by muting its endogenous reaction to relative prices. The choice of a finite time horizon with two periods is motivated by simplicity. We study the effect of uncertainty by examining the impact of labor income risk on the allocation of time and consumption, relative to a deterministic economy.

[11] The corresponding F-statistic is 115.34, with a p-value smaller than 0.001.

[12] The literature that estimates local projections using fiscal-policy shocks identified as in Blanchard and Perotti (2002) follows a similar approach.

[13] We set $p = 9$ and $p = 3$, respectively.

[14] In annualized percentage points, a one-standard deviation shock raises the level of the VXO to about 25.5%, from its unconditional average of about 19%.

[15] Appendix A also presents the responses of a set of macro variables (real GDP, market consumption, investment and the price level).

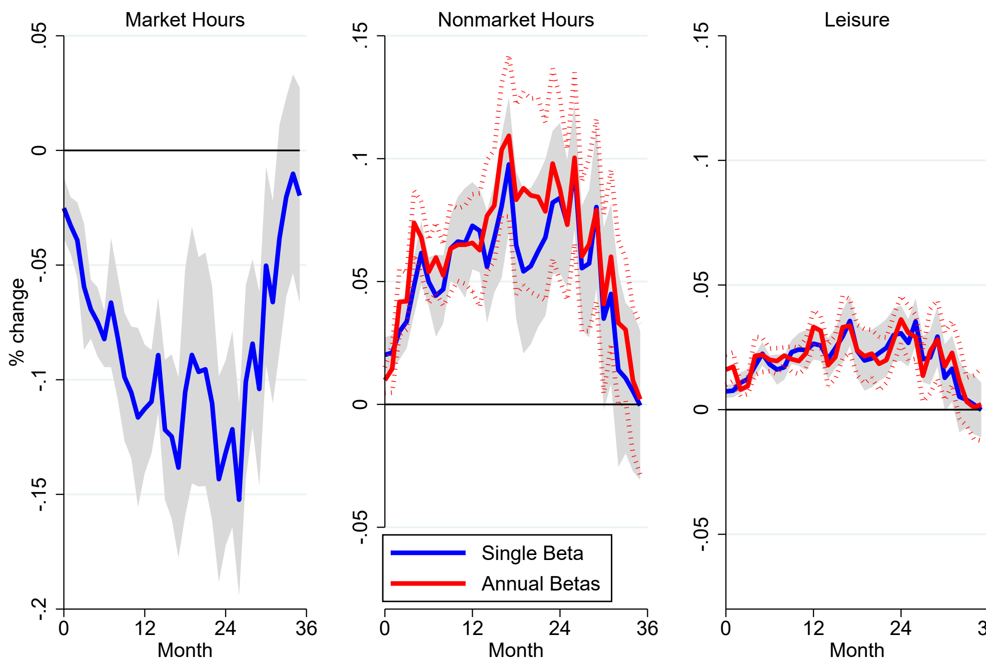


Figure 1: Estimated impulse responses and 90% confidence intervals for hours worked (from CPS), nonmarket hours and leisure time, conditional on a one-standard-deviation uncertainty shock, using data from 1994:M1–2019:M12. Nonmarket hours and leisure time series are constructed with β^j from (2) estimated over the entire ATUS data from 2003–2019 (blue line, labeled as 'average beta'), and alternatively with β_t^j from (3) estimated year by year (red line, labeled as 'annual betas').

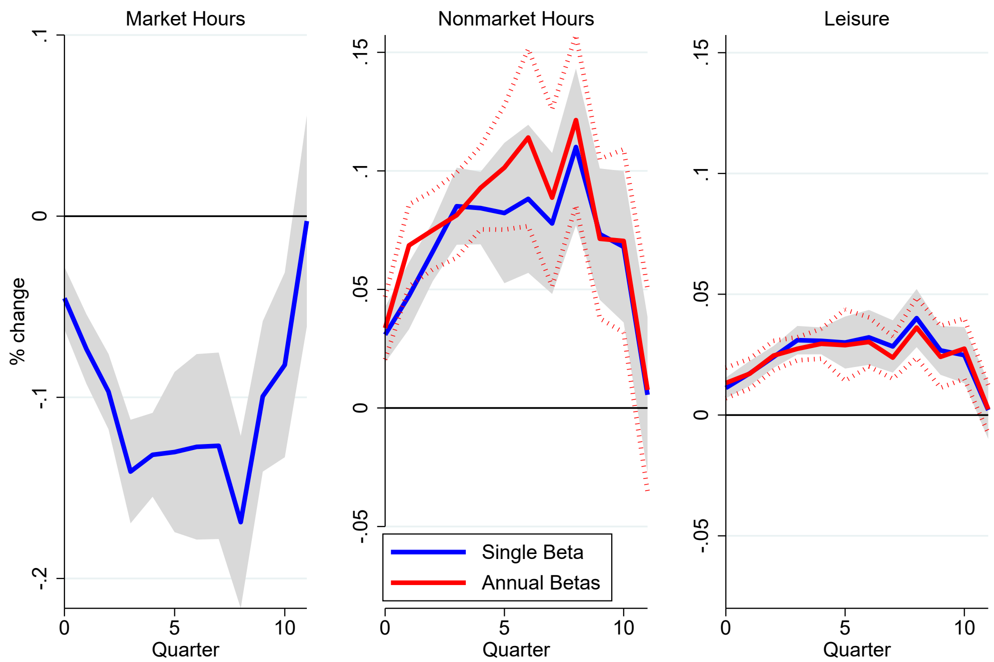


Figure 2: Estimated impulse responses and 90% confidence intervals for hours worked (from CPS), nonmarket hours and leisure time, conditional on a one-standard-deviation uncertainty shock, using data from 1994:Q1–2019:Q4. Nonmarket hours and leisure time series are constructed with β^j from (2) estimated over the entire ATUS data from 2003–2019 (blue line, labeled as 'average beta'), and alternatively with β_t^j from (3) estimated year by year (red line, labeled as 'annual betas').

The household's problem

The time endowment is normalized to 1 and the household can allocate it to market work, $h_{m,t}$, in exchange for a real wage w_t, or to housework, $h_{n,t}$, which produces home goods according to the following linear technology,

$$C_{n,t} = h_{n,t}, \tag{7}$$

and residual time is enjoyed as leisure, L_t , so that

$$h_{m,t} + h_{n,t} + L_t = 1. \tag{8}$$

The flow budget constraint reads as

$$b_{t-1} + w_t h_{m,t} \geq C_{m,t} + r_t^{-1} b_t, \tag{9}$$

where $C_{m,t}$ denotes goods purchased on the market, b_{t-1} is a stock of non-contingent zero-coupon real bonds that pay one unit of the market good, and b_t is the stock of bonds that the household can carry into the next period at a risk-free real return $r_t > 1$.

After aggregating market and home goods at a constant elasticity $1/(1 - b_1)$ into total consumption, C_t,

$$C_t = \left[\alpha_1 (C_{m,t})^{b_1} + (1 - \alpha_1)(C_{n,t})^{b_1}\right]^{\frac{1}{b_1}}, \quad \alpha_1 \in [0, 1] \quad b_1 < 1, \tag{10}$$

the households' problem can be defined as the one of choosing a state-contingent path for all variables so as to maximize utility

$$E_1 \sum_{t=1}^{2} \beta^t U(C_t, L_t), \tag{11}$$

subject to constraints (7) to (10), for a given initial value of the stock of bonds b_0. We assume that utility is increasing in both arguments and concave.

Optimality conditions and equilibrium

Let λ_t denote the marginal utility of market consumption:

$$\lambda_t = U_C(C_t, l_t)\alpha_1 \left(\frac{C_{m,t}}{C_t}\right)^{b_1 - 1}, \tag{12}$$

where U_C stands for the derivative of utility with respect to total consumption C_t.

The solution to the household's problem needs to satisfy two intra-temporal conditions:[16]

$$w_t = \frac{U_l(C_t, l_t)}{\lambda_t}, \tag{13}$$

$$1 = \frac{U_l(C_t, l_t)}{(1-\alpha_1)U_C(C_t, l_t)} \left(\frac{C_{n,t}}{C_t}\right)^{1-b_1} \tag{14}$$

where U_L stands for the derivative of utility with respect to leisure. Equation (13) is the standard optimality condition solving for the allocation of time between leisure and market consumption. Equation (14) captures the additional housework-leisure tradeoff and equalizes the relative price of home consumption in terms of leisure, i.e., the marginal productivity of labor in the non-market sector, displayed on the left-hand side, to the corresponding marginal rate of substitution.

Finally, a conventional Euler equation and a terminal condition are required for the choice of bonds to be optimal inter-temporally:

$$\frac{\lambda_1}{r_1} = \beta E_1 \{\lambda_2\}, \qquad b_2 = 0. \tag{15}$$

Optimality conditions (12)-(15) and constraints (7)-(10) define the equilibrium allocation i.e., the optimal quantities C_t, $C_{m,t}$, $C_{n,t}$, $h_{m,t}$, $h_{n,t}$, L_t and b_t, as well as λ_t, for a given probability distribution of prices w_t and r_t.

The interpretation of results is eased by introducing Frisch functions, along the lines of Frisch (1959), Browning, Deaton, and Irish (1985) and Hall (2009b).[17] They are implicitly defined by equations (7), (8), (10), and (12)-(14), which are indeed sufficient to determine consumption and time use given w_t and λ_t. These functions disentangle intra-temporal and inter-temporal channels through which time allocation affects the transmission of uncertainty. In fact, the marginal utility of consumption embodies the entire forward-looking optimization of the household, based on the expected life-time income profile. Hence, the elasticity of time use to the real wage for a constant value of λ_t singles out an intra-temporal channel, according to which the household optimally responds to the market price of time, conditionally on having inter-temporally allocated life-time income optimally. The elasticity to λ_t highlights instead an inter-temporal channel, according to which the households reallocate time even though the contemporaneous relative price of time remains constant, because, for example, the volatility of future income has varied. Frisch functions

[16] See Appendix TBW for derivations

[17] We show in the Appendix TBW that Frisch functions can also be defined for the case of non-time separable preferences, as in Epstein-Zin, which we will consider in the general equilibrium analysis that follows.

are plotted and interpreted in the next section.

Results

To analyze the effects of uncertainty we compare a deterministic economy with one that features labor income risk. In the first economy, prices are set at the deterministic steady state of the general equilibrium model discussed in the next section. In the latter, for the first period the wage, w_1, is known and equal to the level it takes in the deterministic economy. In the second period, instead, it can take values w_L or w_H, $w_L < w_H$, with a 50 percent probability, and such that its expected value is equal to w_1. We consider various mean preserving spreads of the wage, so as to span a range for its percentage standard deviation roughly between 5 and 45 percent.

We need to parameterize the model in order to solve it numerically. Although we choose most of parameters on an empirically relevant range, at this stage the analysis remains qualitative and exclusively aimed at discerning the main mechanisms at play. A more careful quantitative assessment is postponed to the general equilibrium section. We specify the period utility function as

$$U(C_t, L_t) = \frac{\left(C_t^{\eta} L_t^{1-\eta}\right)^{1-\sigma} - 1}{1-\sigma}, \tag{16}$$

and choose parameters as in the general equilibrium model.[18] To highlight the role that substitution between market hours and housework plays for the propagation of uncertainty, in our experiments, we either let vary the elasticity of substitution between home and market goods, b_1, or we compare the home production economy with one where housework is constant, and fixed to the value it takes in the deterministic version of the home production model.[19] In the latter case, for illustrative purposes, we fix $b_1 = 2/3$.

We first examine the overall effect of allowing for substitution between hours worked and housework on the conventional precautionary motives spurred by heightened uncertainty. We do so by computing (Figure 3) equilibrium bond holdings, market consumption, hours worked, housework and leisure in period 1 for different values of the standard deviation of the real wage in period 2, represented on the horizontal axis, and for different values of the elasticity of substitution between home and market goods. We compare results with the economy where home production is held

[18] The initial stock of bonds b_0 is picked so that hours worked on the market and at home are roughly 0.33 and 0.19, respectively, which are the values used to calibrate the general equilibrium model later on. The implied value is $b = 0.5$.

[19] Parameter b_1 is varied on an empirically relevant range, consistent with an elasticity of substitution between 1.5 and 4. Cite ourselves.

constant. The additional substitution margin attenuates precautionary motives by dampening the fall in market consumption and the rise in hours worked on the market that typically follow a spike in uncertainty. For any level of the standard deviation of the real wage in period 2, both market consumption and hours worked on the market are indeed less responsive, the larger is the substitutability between home and market goods, and relative to the model without home production. Notice that housework, similar to leisure, falls with uncertainty, moving in the opposite direction of hours worked. The intuition of the result can be explained with the fact that home goods, like market goods and leisure, are normal goods. Hence, at uncertainty times, households, similar to the case of a negative shock to wealth, prefer to reduce out of precaution all goods and work more, so as to build a buffer against future expected volatility in market consumption. Time reallocation thus overall appears to be an effective self-insurance tool, mitigating, at given prices, the effects of uncertainty on the equilibrium allocation.

To gain further economic intuition, Figure 4 plots Frisch functions for hours worked, housework, total consumption and market consumption in the models with and without home production where $b_1 = 2/3$. It is evident that when households can reallocate time freely, for a given value of λ, and therefore for motives that purely relate to the substitution induced by a change in the market price of time, housework negatively co-moves with the real wage. As an implication, market hours become more elastic. In other words, as the real wage and thus labor income falls, the household compensates the shortfall in market expenditure with housework and an increase in the consumption of home goods, contributing to stabilize fluctuations in total consumption. It is thus this substitution that makes housework an effective self-insurance tool when shocks to labor income materialize, as in period 2 of our model, attenuating precautionary motives in period 1.

One may be tempted to conclude that housework, by dampening precaution, would also mitigate the recession that follows an uncertainty shock when prices are sticky, in light of the fact that it is the rise in precautionary savings and the subsequent fall in the demand for market goods that triggers the recession in such a context. However, together with better self-insurance to labor income shocks, and then lesser precautionary savings, home production also brings about a larger complementarity between market consumption and hours worked, which is highlighted in Figure 4, where the Frisch function for market consumption is plotted. Market consumption and hours worked are defined to be (Frisch) complements if consumption expenditure falls with the real wage, even if life-time income is controlled for (i.e. for λ_t constant). As an implication, on the one hand, aggregate demand falls by less out of precaution, and on the the other hand it falls by more due to

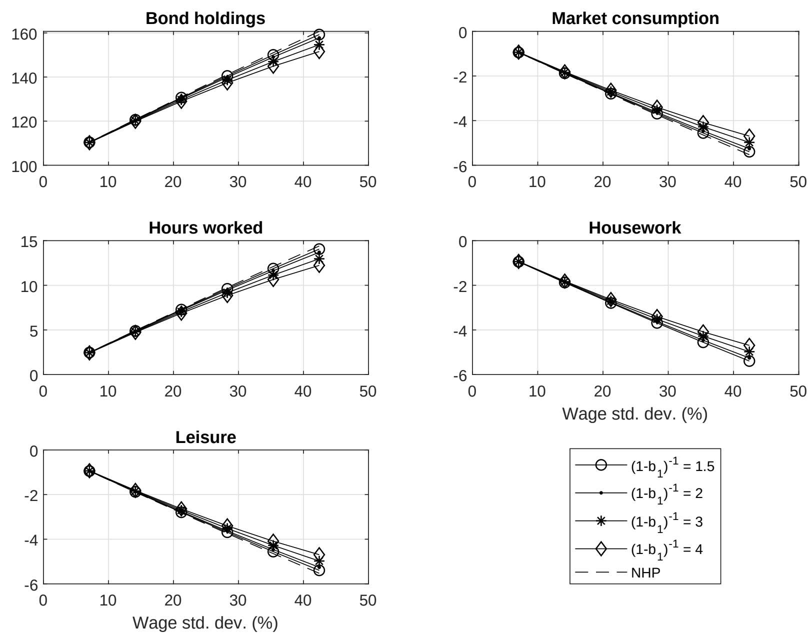


Figure 3:

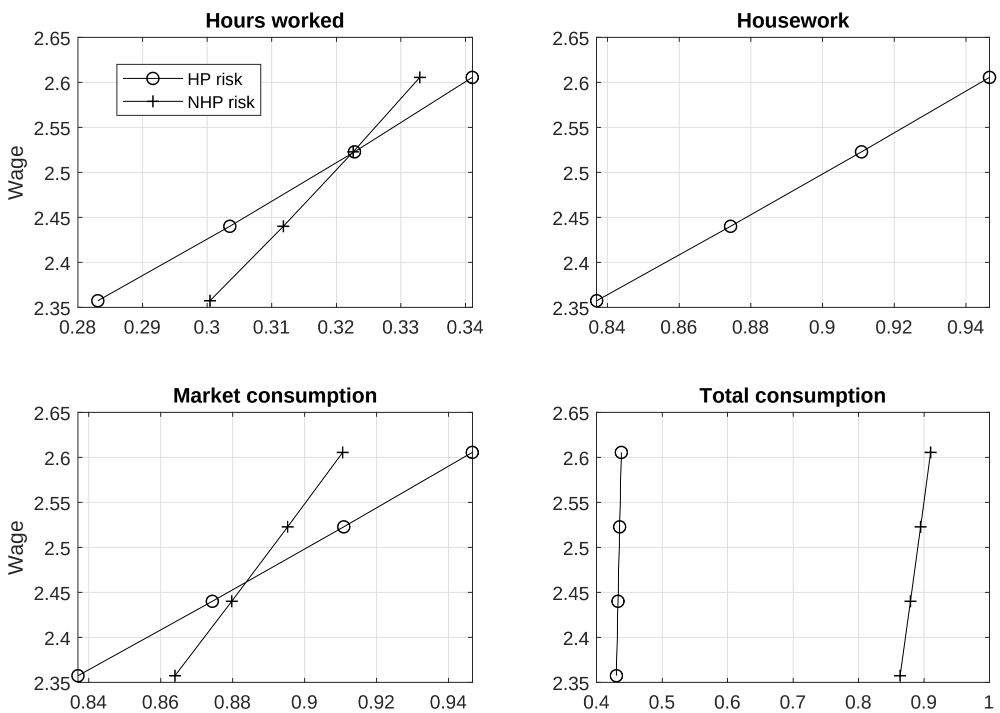
the complementarity with hours worked, or, in other words, due to the greater responsiveness to the market price of time, which typically falls in recessions.

In sum, home production affects the transmission of uncertainty shocks along two margins: an inter-temporal margin, which works through a wealth effect that leaves households better insured against income shocks and thus less inclined to save, and an intra-temporal margin, which works through a substitution effect that is due to the complementary between market expenditure and market hours worked. Those two margins affect the transmission of uncertainty in opposite directions.

What the net effect may be depends on which one of the two margins quantitatively prevails, which motivates the introduction of our general equilibrium analysis of the next section.

4 General Equilibrium Analysis

As discussed in the previous section, the PE model cannot whether time-use (and expenditures) reallocation ultimately results in a higher or smaller elasticity of aggregate output to uncertainty. Second, the PE model abstracts from the implications of uncertainty for firms' labor demand and real wages, which also affect households' incentive to reallocate time use.



Hours worked
Housework
Market consumption
Total consumption
Wage
HP risk
NHP risk
2.65
2.6
2.55
2.5
2.45
2.4
2.35
0.28
0.29
0.3
0.31
0.32
0.33
0.34
0.84
0.86
0.88
0.9
0.92
0.94
0.4
0.5
0.6
0.7
0.8
1

Figure 4:

We build a benchmark general-equilibrium model of housework and time-varying uncertainty to quantify the importance of time-use variation for the aggregate transmission of uncertainty. We embed the PE model of housework of Section 3 into a dynamic stochastic general equilibrium model that features both first- and second-moment shocks. Except for the modelling of housework, the model follows Basu and Bundick (2017), Born and Pfeifer (2014), and Fernandez-Villaverde, Guerron-Quintana, Kuester, and Rubio-Ramirez (2015). These papers develop what is today considered a benchmark framework to study macroeconomic dynamics following aggregate uncertainty shocks. As in Basu and Bundick (2017), we focus on uncertainty about future aggregate demand, assuming that exogenous discount rate shocks have a time-varying second moment. Thus, in contrast to the PE model of Section 3, income uncertainty becomes an endogenous equilibrium outcome.

Model

The model features optimizing households and firms. Producers' demand is downward sloping due to sticky prices. As discussed by Basu and Bundick (2017), demand-determined output (at least over some time horizon) implies that uncertainty shocks cause shifts in labor demand, which in turn are central for standard business cycle models to reproduce the comovement in macroeconomic variables estimated in the data.[20] Since the modelling of the asset and production structure follows Basu and Bundick (2017) closely, here we only discuss the model's main features. Appendix B contains the detailed derivation of all the equilibrium conditions.

Households

There is an infinitely lived representative household that maximizes lifetime utility over streams of consumption and leisure, C_t and L_t. We now assume Epstein–Zin preferences:

$$V_t = \max \left\{ a_t \left[U(C_t, l_t)\right]^{\frac{1-\sigma}{\theta_v}} + \beta \left(\mathbb{E}_t V_{t+1}^{1-\sigma}\right)^{\frac{1}{\theta_v}} \right\}^{\frac{\theta_v}{1-\sigma}}, \tag{17}$$

where σ is the parameter controlling risk aversion over the consumption-leisure basket, and ψ is the intertemporal elasticity of substitution.[21] The parameter $\theta_v = (1-\sigma)(1-1/\psi)^{-1}$ controls

[20] Countercyclical markups through sticky prices are also important to overcome the attenuation of the effects of uncertainty shocks observed in the standard neoclassical growth model (Basu and Bundick, 2017). Other mechanisms can deliver amplification and empirically-plausible macroeconomic comovement, including modelling several assets and agents' heterogeneity (e.g., Fernandez-Villaverde, Guerron-Quintana, Kuester, and Rubio-Ramirez, 2015) or ambiguity aversion (e.g., Ilut and Schneider, 2014).

[21] Our main qualitative results are robust to using standard expected utility preferences as in 16. Recursive preferences à la Epstein and Zin allow increasing risk aversion (helping the model generate quantitatively plausible

the household's preference for the resolution of uncertainty. As in the partial-equilibrium model of Section 3, the period utility function is $U(C_t, L_t) = (C_t)^{\eta} (l_t)^{1-\eta}$, and the time endowment is normalized to 1. Equations (7) and (10) still determine preferences over market- and home-produced goods, $C_{m,t}$ and $C_{n,t}$, and the home production technology. The household's discount rate β is subject to shocks via the exogenous stochastic process a_t.

The household receives labor income W_t for each unit of labor $h_{m,t}$ supplied to intermediate goods-producing firms. The representative household owns the intermediate goods firm and holds equity shares S_t and one-period riskless bonds B_t issued by the representative intermediate goods firm. Equity shares have a price of P_t^E and pay dividends D_t^E for each share S_t owned. The riskless bonds return the gross one-period risk-free interest rate R_t^R. The household divides its income from labor and its financial assets between consumption of market goods, $C_{m,t}$, and holdings of financial assets S_{t+1} and B_{t+1} to carry into the next period.

The household maximizes (17) subject to its intertemporal budget constraint each period:

$$C_{m,t} + \frac{P_t^E}{P_t} S_{t+1} + \frac{1}{R_t^R} B_{t+1} = \frac{W_t}{P_t} h_{m,t} + \left(\frac{D_t^E}{P_t} + \frac{P_t^E}{P_t} \right) S_t + B_t,$$

where P_t is the price index of the aggregate consumption bundle. Epstein–Zin utility implies the following stochastic discount factor M between periods t and $t+1$:

$$M_{t+1} \equiv \beta \frac{a_{t+1}}{a_t} \left(\frac{U(C_{t+1}, l_{t+1})}{U(C_t, l_t)} \right)^{\frac{1-\sigma}{\theta_v} - 1} \frac{U_c(C_{t+1}, l_{t+1})}{U_c(C_t, l_t)} \left(\frac{C_{m,t+1}}{C_{m,t}} \frac{C_t}{C_{t+1}} \right)^{b_1 - 1} \left(\frac{V_{t+1}^{1-\sigma}}{\mathbb{E}_t V_{t+1}^{1-\sigma}} \right)^{1 - \frac{1}{\theta_v}}.$$

Producers

The representative intermediate good-producing firm i rents labor $h_{m,t}(i)$ from the representative household to produce intermediate good $Y_t(i)$. Intermediate goods are produced in a monopolistically competitive market where producers face a quadratic cost ϕ_p of changing their nominal price $P_t(i)$ each period. Intermediate goods producers own their capital stocks $K_t(i)$, and face convex costs ϕ_k of changing the quantity of installed capital. Each firm issues equity shares $S_t(i)$ and one-period risk-less bonds $B_t(i)$. Firmi chooses $h_{m,t}(i)$, $I_t(i)$, and $P_t(i)$ to maximize firm cash flows $D_t(i)/P_t(i)$ given aggregate demand Y_t and the price P_t of the finished goods sector. The intermediate goods firms have a constant-returns-to-scale Cobb–Douglas production function, subject to a

aggregate effects of uncertainty) while keeping the relatively high intertemporal elasticities of substitution needed to ensure sound business cycle properties for the model (see Fernandez-Villaverde and Guerron-Quintana, 2020).

fixed cost Γ:

$$Y_t(i) = K_t^{\alpha} \left(Z_t h_{m,t}\right)^{1-\alpha} - \Gamma,$$

where Z_t denotes productivity. Each maximizes discounted cash flows using the household's stochastic discount factor subject to the production function and the capital accumulation equation:

$$K_{t+1}(i) = \left[1 - \delta - \frac{\phi_k}{2}\left(\frac{I_t(i)}{K_t(i)} - \delta\right)^2\right] K_t(i) + I_t(i).$$

Each intermediate goods firm finances a percentage ν of its capital stock each period with one-period risk-less bonds. The bonds pay a one-period real risk-free interest rate. Thus, the quantity of bonds $B_t(i) = \nu K_t(i)$. Total firm cash flows are divided between payments to bond holders and equity holders. Since the Modigliani and Miller (1958) theorem holds, leverage does not affect firm optimal firm decisions. Leverage allows us to define a concept of equity returns, which in turn we use to construct a measure of uncertainty consistent with the VXO.

The representative final goods producer j uses intermediate goods as an input. The market for final goods is perfectly competitive. The aggregate price index $P_t \equiv \left[\int_j P_t^{1-\theta_\mu}(j)\, dj\right]^{1/(1-\theta_\mu)}$, where θ_μ denotes the elasticity of substitution among intermediate goods.

Monetary Policy and Aggregate Shocks

We resort to a cashless economy following Woodford (2003). The monetary authority sets the nominal interest rate $r_t \equiv \log R_t$ to stabilize inflation and output growth:

$$r_t = \bar{r} + \rho_\pi \left(\pi_t - \bar{\pi}\right) + \rho_y \Delta y_t,$$

where $\pi_t \equiv \log\left(P_t/P_{t-1}\right)$, $\Delta y_t \equiv \log\left(Y_t/Y_{t-1}\right)$, and variables without time subscript denote steady-state values.

The demand and technology shock processes are parameterized as follows:

$$a_t = (1-\rho_a)\bar{a} + \rho_a a_{t-1} + \sigma_{t-1}^a \epsilon_t^a,$$

$$\sigma_t^a = (1-\rho_{\sigma_a})\bar{\sigma}_a + \rho_{\sigma_a}\sigma_{t-1}^a + \sigma^{\sigma_a}\epsilon_t^{\sigma_a},$$

$$Z_t = (1-\rho_z)\bar{Z} + \rho_z Z_{t-1} + \sigma_z \epsilon_t^z.$$

The terms ϵ_t^a and ϵ_t^z are first-moment shocks that capture innovations to the level of the household discount factor and technology. The term $\epsilon_t^{\sigma_a}$ is a second-moment or "uncertainty" shock since it captures innovations to the volatility of the household discount factor. An increase in volatility increases uncertainty about the future time path of households' demand. All three stochastic shocks are independent, standard normal random variables. We specify the stochastic processes in levels rather than logs to prevent σ_t^a from impacting the average value of a_t through the Jensen's inequality.

Calibration and Solution Method

Calibration

We interpret periods as quarters and parametrize the model to match U.S. macroeconomic data. Following standard practice in the home-production literature (e.g., Gnocchi, Hauser, and Pappa, 2016b), we set the capital share in the production function, α, the weight on market consumption in total consumption, a_1, and the elasticity of substitution between consumption and leisure, η, such that the steady-state capital-output ratio, K/Y, is 5.15, hours worked on the market, h_m, equal to 0.33, and hours worked at home, h_n, equal to 0.19.[22] We set the elasticity of substitution between market and nonmarket goods, $1/b$, equal to 2.

The calibration of the remaining parameters follows Basu and Bundick, 2017. The discount factor β is equal to 0.994, the intertemporal elasticity of substitution ψ is 0.95, and risk aversion over the consumption-leisure basket σ is equal to 80. We set the fixed cost of production Γ to eliminate pure profits in the deterministic steady state of the model. The capital depreciation rate δ is 0.025, while the investment adjustment cost is $\phi_k = 2$. The price adjustment cost parameter is $\phi_p = 100$, which implies prices are reset about once every four quarters in a linearized Calvo setting. The elasticity of substitution of intermediate goods, θ_μ, is equal to 6. The parameters governing the monetary policy reaction to inflation and output are $\rho_\pi = 1.5$ and $\rho_y = 0.2$. The quarterly gross steady-state inflation rate is $\Pi = 1.005$, corresponding to a two-percent annualized inflation target.

Basu and Bundick, 2017 calibrate the parameters of first- and second-moment shocks such that their model produces fluctuations in uncertainty that are consistent with the VXO, an observable indicator of ex-ante stock market volatility. We use the same parametrization and verify the model-

[22] The figures for h_m and h_n obtain after subtracting from the weekly time endowment sleeping, personal care, and eating. Including such activities, market work and home production time would be 0.18 and 0.11, respectively.

VXO dynamics are consistent with the data when studying impulse responses below. To this end, we construct a model-implied VXO index, $\mathbb{V}_t$, as the expected conditional volatility of the return on firm equity:

$$\mathbb{V}_t = 100 * \sqrt{4 * \mathbb{VAR}_t R_t^E}, \tag{18}$$

where $\mathbb{VAR}_t R_t^E$ is the quarterly conditional variance of the return on equity. We annualize the quarterly conditional variance and then transform the annual volatility units into percentage points. Appendix B summarizes the model calibration.

Solution Method

We approximate the model policy functions by computing a fourth-order Taylor expansion of the equilibrium conditions around the deterministic steady state. We rely on a fourth-order approximation since, up to the third order, the approximated policy functions do not preserve important properties of the non-linear equilibrium conditions of the model (e.g., Cacciatore and Ravenna, 2021).

Time Use and the Macroeconomic Effects of Uncertainty

We now discuss how time-use reallocation affects the transmission of uncertainty shocks. Towards this end, we first study the impulse responses to a one-standard-deviation uncertainty shock. Next, we consider a counterfactual experiment in which home production ($h_{n,t}$) is held constant at its steady-state level following the same uncertainty shock. In this counterfactual model, households can only reallocate time between market hours and leisure.

Figure 4 (continuous lines) shows that in the model with housework, higher uncertainty results in lower market hours ($h_{m,t}$) and higher home production. The impulse responses are quantitatively consistent with the empirical estimates presented in Figure (Section 2). Furthermore, as housework increases, households reallocate expenditures towards nonmarket consumption, other things equal. Aggregate investment, output, and inflation decline. Appendix C shows that the responses of these variables, as well as the model-implied VXO in (18), in general, lie within the confidence bands of local-projection estimates that use the same uncertainty shock identified in Section 2.

To understand these findings, recall first the insights from the partial-equilibrium analysis. As uncertainty rises, households' precautionary saving and precautionary labor supply increase. Precautionary savings reduces aggregate demand. Other things equal, consumption of market goods declines, lowering investment and labor demand. While precautionary saving reduce demand for all goods (inclusing housework and leisure) other things equal, in equilibrium, households reallocate time from market hours to housework since real wages fall. Thus, $h_{m,t}$ falls while $h_{n,t}$ (and nonmarket consumption) increases.

We can now answer our main question of interest: Does reallocation between market and nonmarket work (and the corresponding expenditure reallocation from market to nonmarket goods) mitigate or amplify the macroeconomic effects of uncertainty? Figure 4 (dashed lines) shows that when households cannot adjust hours worked at home, the same uncertainty shock results in a smaller contraction of output and hours worked but a larger drop in total consumption. Moreover, the decline in wages (and thus inflation) is larger. Quantitatively, time-use reallocation increases the output contraction by roughly one-fourth relative to the counterfactual scenario.

The intuitions from the partial-equilibrium model also rationalize these findings. Although precautionary motives are weakened, time reallocation lowers aggregate demand, amplifying the contractionary effects of uncertainty. The reason is that time reallocation induces complementarity between market-hours work and consumption expenditures on market goods. Thus, a given income decline results in intratemporal substitution of market expenditures with home goods that would not be feasible in the absence of home production. The higher aggregate demand elasticity to uncertainty ultimately explains the more severe recession. This effect explains about one-fourth of the decline in aggregate output.

5 Macroeconomic Policy and Substitution Towards Housework

Thus far, the analysis has focused on how uncertainty affects households' incentives to reallocate time use due to precautionary motives. The eruption of the COVID-19 pandemic, one of the largest sources of macroeconomic uncertainty in modern history, also brought to the forefront of policy and academic discussions the role of macroeconomic policies that induce households' time use reallocation on a large scale. The shutting down of contact-intensive sectors, the fear of contagion, and the lockdowns that encompassed stay-at-home orders, curfews, and similar societal restrictions forced households to cut expenditures on market-produced goods and employment-related activities (e.g., accommodation and food services, commuting) while increasing housework (e.g., childcare, meal preparation, cleaning, etc.).

In this last section, we discuss how policies that directly affect time use allocation (a first-

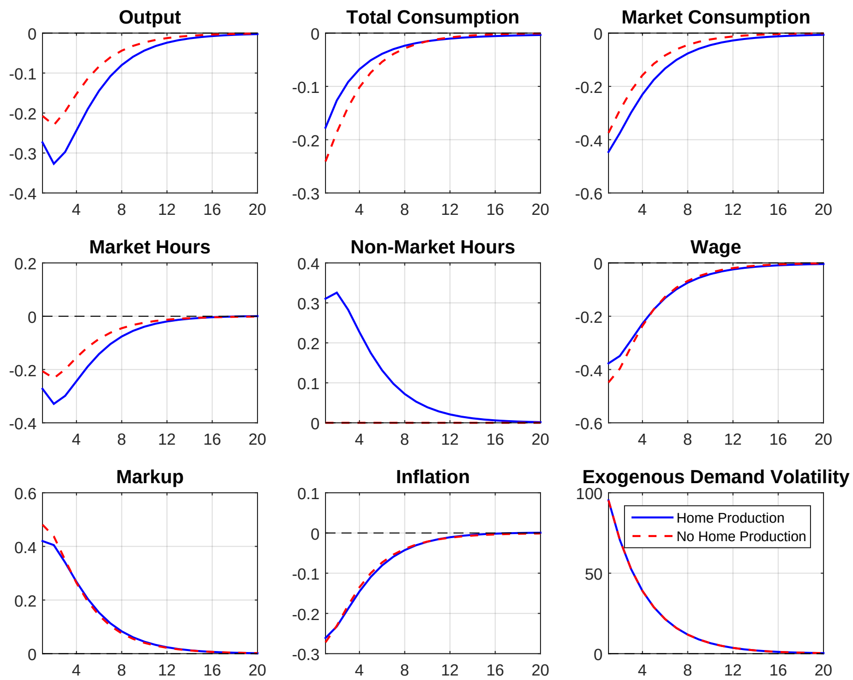


Figure 5: Impulse responses following a one-standard-deviation uncertainty shocks. The continuous line represents the baseline model of housework; the dashed line represents a counterfactual economy where home production is constant. Variables are in percentage deviations from the steady state, except for inflation, which is annualized.

moment effect) can interact with the effects of uncertainty. We model such policies assuming that government interventions change the weight of market consumption in the CES total consumption aggregator in equation (10)—the parameter α_1. Our reduced-form approach keeps the analysis simple by proxying a policy intervention with a change in preferences. In this regard, the approach parallels the literature that studies the macroeconomic effects of trade openness, which focuses on changes in the degree of consumers' home bias.

Figure 5 plots impulse responses following an exogenous 1% increase in the consumption share of nonmarket goods (holding uncertainty constant). As households reallocate expenditure shares, housework increases. In contrast, market hours, aggregate demand, and output fall. Wages increase to clear the labor market, and the real marginal cost and inflation increase. Qualitatively, aggregate dynamics are identical to the effects of endogenous time reallocation induced by an uncertainty increase—measured by the difference between the continuous and dashed lines in Figure 4. Thus, policies that induce households to substitute market hours with housework compound the adverse effects on aggregate demand and output brought about by time-use variation at times of heightened uncertainty.

To conclude the analysis, we conduct a final heuristic experiment that studies the implications of an increase in uncertainty accompanied by a policy that induces households to reallocate time use. We calibrate the size of the uncertainty shock, σ^{σ_a}, to match the VXO increase observed in March 2020. Concerning the change in the expenditure share on market goods, α_1, we target the total change in home production observed during the pandemic. Since ATUS data collection was suspended altogether during the COVID-19 shutdown (resuming only in mid-May), time diary-based information does not exist between March and May 2020. Thus, we can only use an estimate of time allocation patterns during the pandemic recession. We rely on the cyclical substitution rate estimated in Section 2 to infer the change in housework from the variation in hours market work. The approach follows Leukhina and Yu, 2022b, who infer the change in home production from the change in average weekly market hours between the months of February and April of 2020.[23] Concerning the shock persistence, much of the March 2020 spike in the VXO faded away

[23] This approach likely underestimates the actual change in home production since our estimates of the foregone market production allocated to home production (the $\beta's$) obtain for a sample period in which time-use reallocative shocks are relatively unimportant (see AHK 2013). An alternative strategy would be to target the overall decline in market hours. However, this alternative strategy would attribute all the change in market hours to either increased uncertainty or policies that induced reallocation from market-goods expenditure towards home-produced goods. This assumption would be too stark and oversimplifying, neglecting other features of the COVID-19 pandemic. For instance, lockdown policies did not always result in substitution from market to home-produced goods (e.g., travelling). Moreover, by holding productivity constant, we would also abstract from the effects of supply chain disruptions.

by August 2020. Moreover, market hours returned to their pre-COVID level a year later. We set the shocks persistence to match these figures.

Figure 5 (continuous lines) plots the impulse responses following the simultaneous increase in volatility and the reduction in the market-goods expenditure. The dashed line plots dynamics for a counterfactual model in which no substitution towards housework is possible: home production is kept constant at its steady-state level, and the government policy is absent. Thus, in the counterfactual economy, the aggregate dynamics correspond to the effects of higher uncertainty in the absence of reallocation between market and nonmarket work.

Figure 5 shows that while higher uncertainty acts as a negative demand shock for a given time allocation, substitution from market to nonmarket hours implied by higher future expected volatility and government policy can result in dynamics consistent with a supply-side shock. Absent any change in macroeconomic policy, the experiment suggests that time-use reallocation could have reduced output by 2 percent and increased annualized inflation by approximately 0.8 relative to the counterfactual scenario. An important caveat when interpreting these results is that our model and analysis abstract from the beneficial effects on output and welfare of policies that limit contagion during a pandemic.

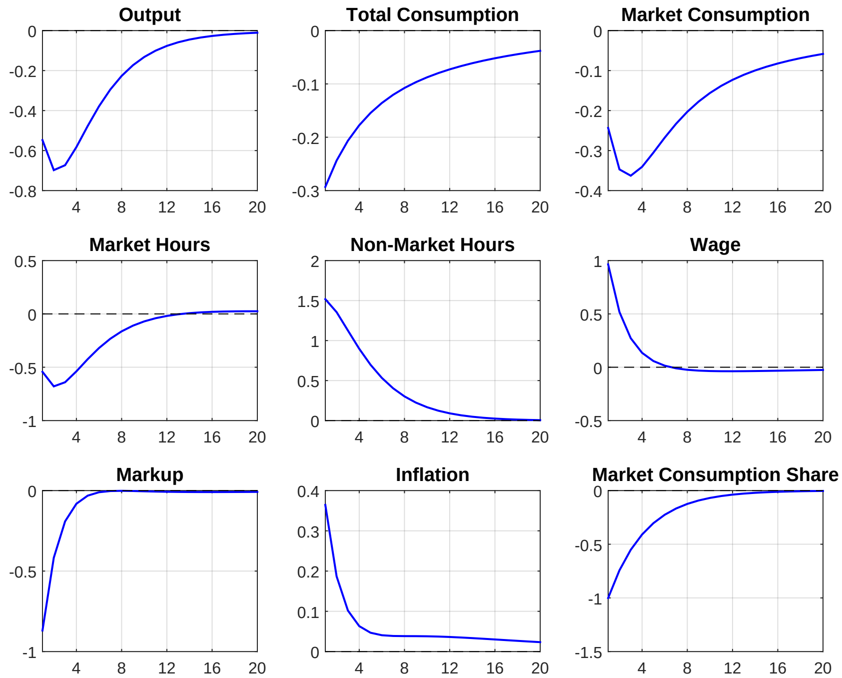


Figure 6: Impulse responses following a one-percent decline in the market-consumption expenditure share. Variables are in percentage deviations from the steady state, except for inflation, which is annualized.

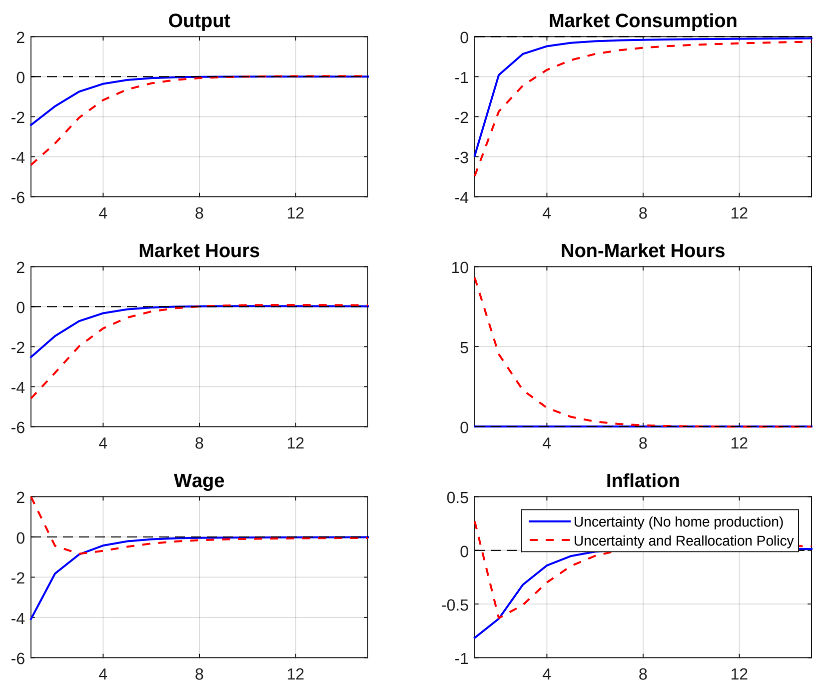


Figure 7: Impulse responses following a joint increase in uncertainty and the market-consumption expenditure share. The continuous line represents the baseline model of housework; the dashed line represents a counterfactual economy where home production is constant. Variables are in percentage deviations from the steady state, except for inflation, which is annualized.

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Online Appendix to: "Time Use and Macroeconomic Uncertainty"

Authors: M. Cacciatore, S. Gnocchi, and D. Hauser

A Time Series Analysis of Time Use

Alternative Definitions of the Dependent Variable

AHK estimate their benchmark regression

$$\Delta\tau^j_{st} = \alpha^j - \beta^j \Delta\tau^{market}_{st} + \varepsilon^j_{st},$$

with $\Delta\tau^j_{st} = \tau^j_{s,t} - \tau^j_{s,t-1}$ defined as the difference in average time spent on activity j in state s from one non-overlapping two-year period to another. In this section we analyze robustness with respect to alternative specifications of $\Delta\tau^j_{st}$, specifically:

- **Annual** state-level data, where $\Delta\tau^j_{st}$ is defined as the year-over-year change in time use of activity j, in state s, for a given year.
- **Quarterly** state-level data, where $\Delta\tau^j_{st}$ captures the year-over-year change in time use of activity j, in state s, for a given quarter.
- **Rolling-window yearly average at quarterly frequency** at the state level, where $\Delta\tilde{\tau}^j_{st}$ captures the year-over-year change in the average time use for activity j in state s, over the last four quarters, i.e. $\tilde{\tau}^j_{st} = mean(\tau^j_{s,t-3}, \tau^j_{s,t-2}, \tau^j_{s,t-1}, \tau^j_{s,t})$.

Table 1 reports estimates based on weighted least squares, where states are weighted by their population, and where changes in demographic variables at the state level are controlled for. Table 2 uses quarterly state-level data to further show that controlling for state-level demographic changes and/or for time-fixed effects does not significantly affect the estimated coefficients.

Robustness: Are the Estimated Coefficients Time Dependent?

TBW

Time Use Category	$\hat{\beta}^j$ biannual 2003–10 (1)	$\hat{\beta}^j$ biannual 2003–2019 (2)	$\hat{\beta}^j$ annual 2003–2019 (3)	$\hat{\beta}^j$ quarterly 2003–2019 (4)	$\hat{\beta}^j$ quarterly rolling window (5)
Nonmarket Work	0.28	0.25	0.25	0.25	0.24
Leisure	0.52	0.60	0.61	0.61	0.61

Table 1: Column 1 reports original estimates in AHK, using ATUS data from 2003–2010. Column 2 reports estimates for the dependent variable defined as biannual state-level differences, using ATUS data from 2003–2019. Column 3 reports estimates based on year-over-year changes, column 4 estimates based on year-over-year quarterly changes, and column 5 estimates on quarterly year-over-year rolling-window averages.

Time Use Category	$\hat{\beta}^j$ *demo* (1)	$\hat{\beta}^j$ *no demo* (2)	$\hat{\beta}^j$ *demo and time* (3)
Nonmarket Work	0.25	0.24	0.24
Leisure	0.61	0.60	0.61

Table 2: Column 1 reports estimates based on quarterly year-over-year changes, when controlling for state-level demographics (*demo*). Column 2 reports estimated coefficients based on quarterly year-over-year changes without controlling for state-level demographic changes (*no demo*). And column 3 reports estimates based on quarterly year-over-year changes with controls for state-level demographic changes and time-fixed effects (*demo and time*).

p-value $H_0 : \beta_t^j = \beta^j$	Nonmarket Work	Leisure
1995	.59	.44
1998	.07	.22
2004	.62	.92
2005	.83	.72
2006	.36	.58
2007	.85	.66
2008	.95	.36
2009	.29	.03
2010	.63	.06
2011	.72	.53
2012	.32	.13
2013	.38	.77
2014	.59	.90
2015	.06	.03
2016	.48	.27
2017	.86	.19
2018	.90	.29
2019	.82	.33

Table 3: P-values for the null hypothesis $H_0 : \beta_t^j = \beta^j$, with β_t^j from (3), when the dependent variable is defined as year-over-year change in time use, and β^j from (2) estimated over the entire sample 2003–2019.

Robustness: Are Home-Production Shocks Important Drivers for Nonmarket Hours?

To rule out the importance of aggregate drivers in explaining cyclical fluctuations of nonmarket hours and leisure we follow AHK (see Section V, p.1689 and following), and estimate the following regression at the individual level:

$$\tau_{ist}^j = \alpha_m - \beta_m^h \tau_{ist}^{market} + \gamma^h \mathbf{A}_{st} + \mathbf{D}_t + \mathbf{S}_s + \delta_m^h \mathbf{X}_{its} + \varepsilon_{ist}^h$$

where τ_{ist}^j denotes hours dedicated to activity j, by individual i in state s in time t, τ_{ist}^{market} denotes market work hours of the individual, $\mathbf{D}_t$ and $\mathbf{S}_s$ are year and state dummies, $\mathbf{X}_{its}$ denotes a vector of demographic and educational controls (the same ones used in the cross-state regressions), and $\mathbf{A}_{st}$ denotes some measure of aggregate labor market conditions at the state level. We consider average work hours in state s in time t from ATUS data ($\mathbf{A}_{st} = \tau_{st}^{market}$), state-level unemployment rate from the BLS ($\mathbf{A}_{st} = u_{st}$), state-level employment to population ratio from the BLS ($\mathbf{A}_{st} = e_{st}$), and state-level labor force participation rate from the BLS ($\mathbf{A}_{st} = p_{st}$). The interpretation of the estimated coefficient γ^h is as follows:

- For $\mathbf{A}_{st} = \tau_{st}^{market}$, $\gamma^h < 0$ implies that individuals spend more time on nonmarket work when aggregate market work hours decrease, holding constant their individual market work hours. This would suggest that individuals experience positive shocks to their nonmarket work time in periods of decreasing aggregate market work. The same logic applies to $\mathbf{A}_{st} = e_{st}$ and $\mathbf{A}_{st} = p_{st}$.
- For the regression using $\mathbf{A}_{st} = u_{st}$, $\gamma^h > 0$ implies that individuals spend more time on nonmarket work when aggregate unemployment is high, holding constant their market work hours. This would suggest that individuals experience positive shocks to their nonmarket work in periods of increasing aggregate unemployment.

In all cases, a statistically significant coefficient γ^h would imply the existence of positive (negative) home production shocks during recessions (expansions). We confirm the main takeaways in AHK using available data from 2003–2019. Specifically, for all specifications we cannot reject the null hypothesis that $\gamma^h = 0$ (at 95%). Hence, individuals adjust their nonmarket and leisure time when their market hours change, but they do not appear to adjust their nonmarket and leisure hours systematically with aggregate labor market conditions (holding their market hours constant). Hence, these regressions show that the aggregate state of the economy (measured either by aggregate market hours or unemployment at the state level) is insignificant in explaining individual home hours once individual market hours are controlled for.

Local Projections with Alternative Uncertainty Measures

This section shows that our results are robust to considering alternative measures of uncertainty. Specifically, instead of including the VXO to identify uncertainty shocks (regression (5) in the main text), we use the indices for macro and financial uncertainty constructed by Jurado, Ludvigson, and Ng (2015). Figures A and A plot time use dynamics conditional on financial uncertainty shocks at monthly and quarterly frequency. Figures TBD and TBD show the same dynamics for macro uncertainty shocks.

B Model Derivation

Here we present the full set of the model equilibrium conditions.

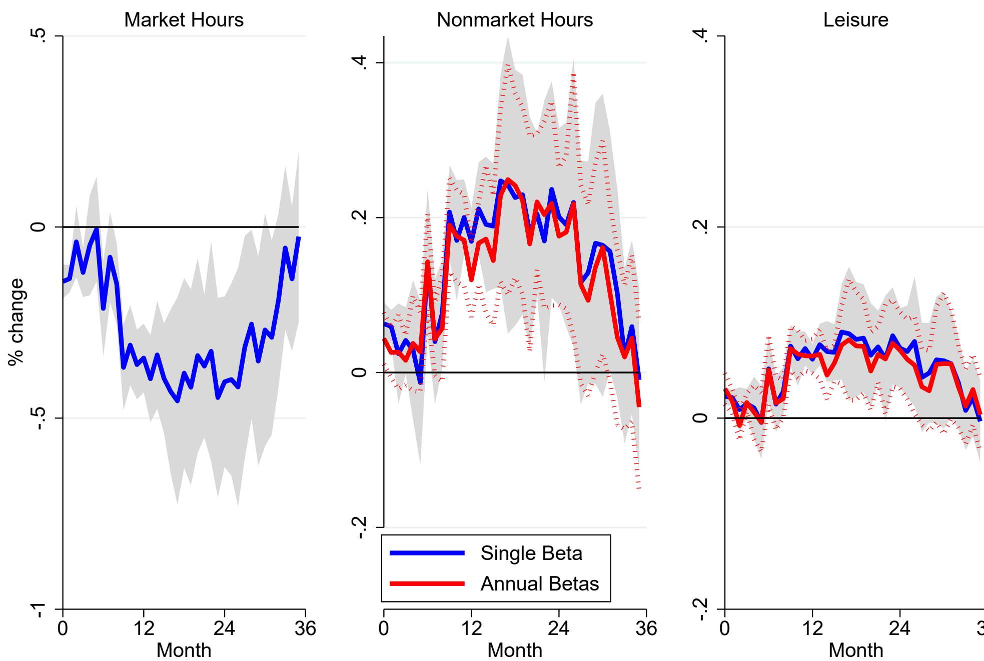

Figure A.1: Estimated impulse responses and 90% confidence intervals for hours worked (from CPS), nonmarket hours and leisure time, conditional on a one-standard-deviation **financial uncertainty** shock, using data from 1994:M1–2019:M12. Nonmarket hours and leisure time series are constructed with β^j from (2) estimated over the entire ATUS data from 2003–2019 (blue line, labeled as 'average beta'), and alternatively with β_t^j from (3) estimated year by year (red line, labeled as 'annual betas').

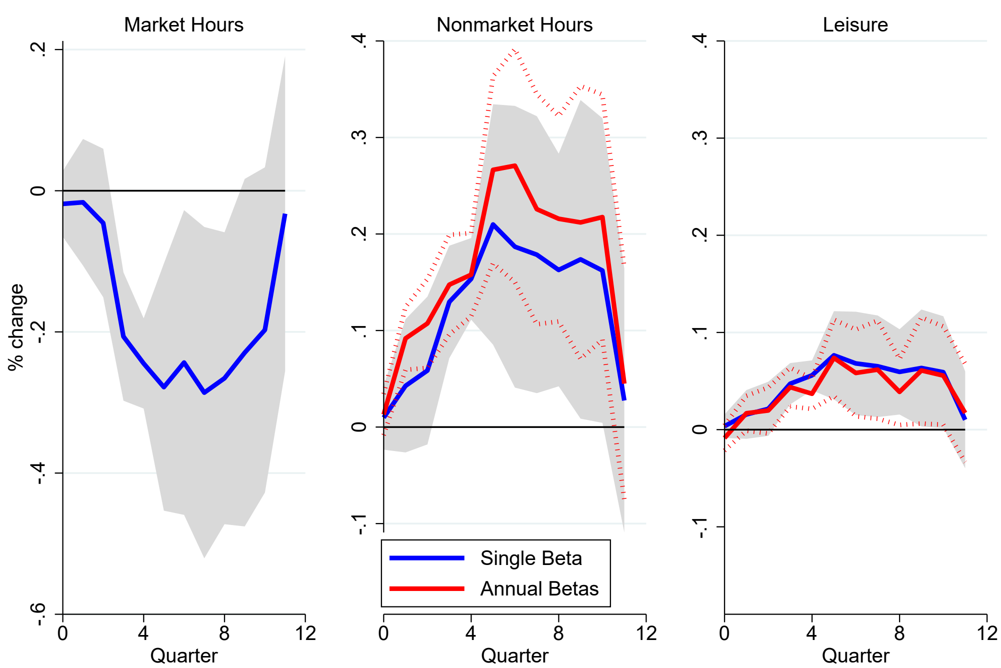

Figure A.2: Estimated impulse responses and 90% confidence intervals for hours worked (from CPS), nonmarket hours and leisure time, conditional on a one-standard-deviation **financial uncertainty** shock, using data from 1994:Q1–2019:Q4. Nonmarket hours and leisure time series are constructed with β^j from (2) estimated over the entire ATUS data from 2003–2019 (blue line, labeled as 'average beta'), and alternatively with β_t^j from (3) estimated year by year (red line, labeled as 'annual betas').

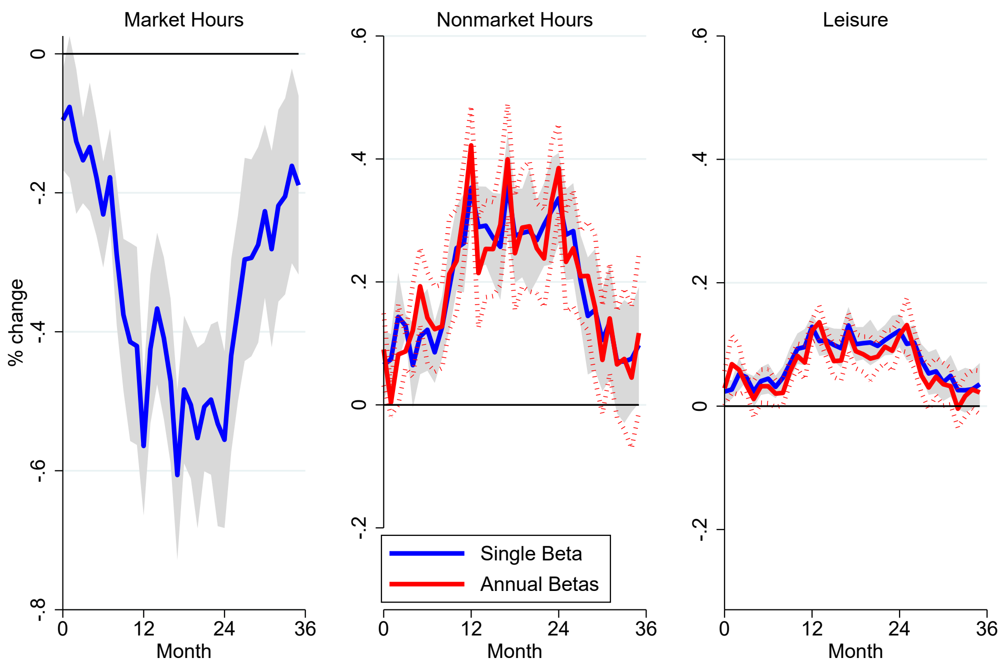

Figure A.3: Estimated impulse responses and 90% confidence intervals for hours worked (from CPS), nonmarket hours and leisure time, conditional on a one-standard-deviation **macro uncertainty** shock, using data from 1994:M1–2019:M12. Nonmarket hours and leisure time series are constructed with β^j from (2) estimated over the entire ATUS data from 2003–2019 (blue line, labeled as 'average beta'), and alternatively with β_t^j from (3) estimated year by year (red line, labeled as 'annual betas').

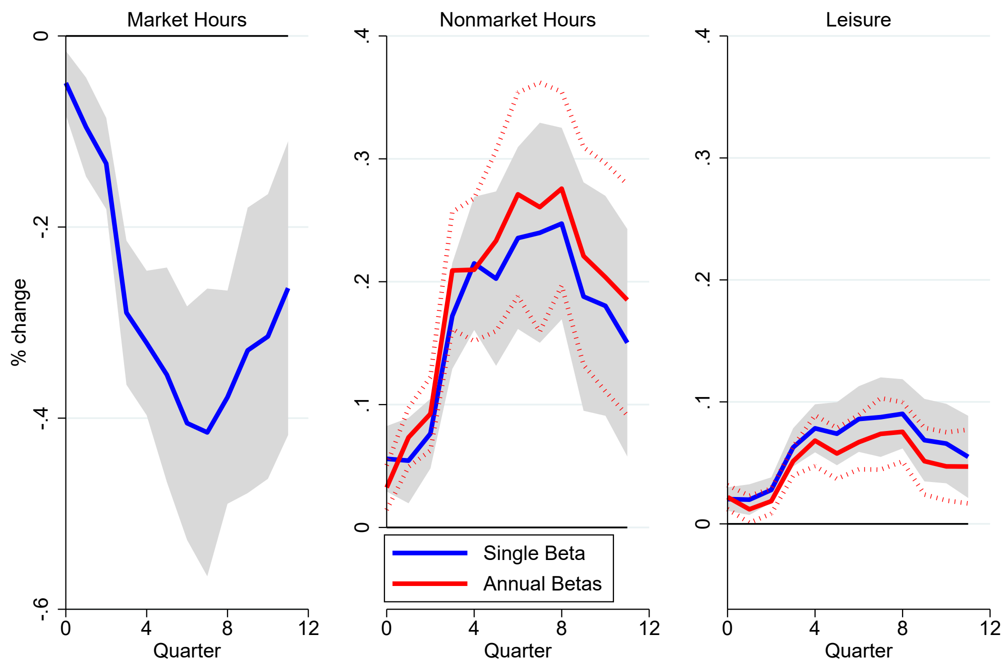

Figure A.4: Estimated impulse responses and 90% confidence intervals for hours worked (from CPS), nonmarket hours and leisure time, conditional on a one-standard-deviation **macro uncertainty** shock, using data from 1994:Q1–2019:Q4. Nonmarket hours and leisure time series are constructed with β^j from (2) estimated over the entire ATUS data from 2003–2019 (blue line, labeled as 'average beta'), and alternatively with β_t^j from (3) estimated year by year (red line, labeled as 'annual betas').

- Welfare function:

$$V_t = \left\{ a_t \left[U(C_t, l_t) \right]^{\frac{1-\sigma}{\theta_v}} + \beta \left(\mathbb{E}_t V_{t+1}^{1-\sigma} \right)^{\frac{1}{\theta_v}} \right\}^{\frac{\theta_v}{1-\sigma}} \tag{A-19}$$

- Stochastic discount factor:

$$M_{t+1} \equiv \beta \frac{a_{t+1}}{a_t} \left(\frac{U(C_{t+1}, l_{t+1})}{U(C_t, l_t)} \right)^{\frac{1-\sigma}{\theta_v} - 1} \frac{U_c(C_{t+1}, l_{t+1})}{U_c(C_t, l_t)} \left(\frac{C_{m,t+1}}{C_{m,t}} \frac{C_t}{C_{t+1}} \right)^{b_1 - 1} \left(\frac{V_{t+1}^{1-\sigma}}{\mathbb{E}_t V_{t+1}^{1-\sigma}} \right)^{1 - \frac{1}{\theta_v}}$$

- Budget constraint:

$$I_{n,t} + C_{m,t} + \frac{P_t^E}{P_t} S_{t+1} + \frac{1}{R_t^R} \nu K_{m,t+1} = \frac{W_t}{P_t} h_{m,t} + \left(\frac{D_t^E}{P_t} + \frac{P_t^E}{P_t} \right) S_t + \nu K_{m,t}$$

- Intratemporal optimality condition (market consumption vs. market hours worked):

$$\frac{W_t}{P_t} = \frac{U_l(C_t, l_t)}{U_c(C_t, l_t)} \frac{1}{\alpha_1} \left(\frac{C_{m,t}}{C_t} \right)^{1-b_1}$$

- First-order condition with respect to equity shares (S_{t+1}):

$$\frac{P_t^E}{P_t} = \mathbb{E}_t \left\{ M_{t+1} \left(\frac{D_{t+1}^E}{P_{t+1}} + \frac{P_{t+1}^E}{P_{t+1}} \right) \right\}$$

- First-order condition with respect to one-period riskless bond (B_{t+1}):

$$1 = R_t^R \mathbb{E}_t \left\{ M_{t+1} \right\}$$

- Production function:

$$Y_t = Z_t^{norm} \left[K_{m,t} U_{m,t} \right]^{\alpha} \left[Z_{m,t} h_{m,t} \right]^{1-\alpha} - \Psi$$

  where Z_t^{norm} is a aggregate TFP, used to normalization steady-state output to one.

- Law of motion for market capital:

$$K_{m,t+1} = \left(1 - \delta(U_{m,t}) - \frac{\phi_{k_m}}{2} \left(\frac{I_{m,t}}{K_{m,t}} - \delta \right)^2 \right) K_{m,t} + I_{m,t}$$

- Market-capital utilization:

$$\delta(U_{m,t}) = \delta + \delta_1 (U_{m,t} - U_m) + \frac{\delta_2}{2} (U_{m,t} - U_m)^2$$

where U_m denotes steady-state capital utilization on the market.

- Cash flows:

$$\frac{D_t}{P_t} = Y_t - \frac{W_t}{P_t} h_{m,t} - I_{m,t} - \frac{\phi_p}{2} \left(\frac{\Pi_t}{\bar{\Pi}} - 1 \right)^2 Y_t$$

- Firms' optimality condition with respect to market hours:

$$\frac{W_t}{P_t} h_{m,t} = (1-\alpha) RMC_t Z_t^{norm} \left[K_{m,t} U_{m,t}\right]^{\alpha} \left[Z_{m,t} h_{m,t}\right]^{1-\alpha}$$

where RMC_t denotes real marginal costs (denoted by χ in the code).

- Firms' optimality condition with respect to market capital:

$$\frac{R_t^K}{P_t} U_{m,t} K_{m,t} = \alpha RMC_t Z_t^{norm} \left[K_{m,t} U_{m,t}\right]^{\alpha} \left[Z_{m,t} h_{m,t}\right]^{1-\alpha}$$

- First-order condition with respect to utilization of market capital:

$$q_t^M \left(\delta_1 + \delta_2 (U_{m,t} - U_m)\right) U_{m,t} K_{m,t} = \alpha RMC_t Z_t^{norm} \left[K_{m,t} U_{m,t}\right]^{\alpha} \left[Z_{m,t} h_{m,t}\right]^{1-\alpha}$$

- Optimal pricing:

$$\phi_p \left(\frac{\Pi_t}{\bar{\Pi}} - 1 \right) \left(\frac{\Pi_t}{\bar{\Pi}} \right) = (1-\theta_\mu) + \theta_\mu RMC_t + \phi_p \mathbb{E}_t \left\{ M_{t+1} \frac{Y_{t+1}}{Y_t} \left(\frac{\Pi_{t+1}}{\bar{\Pi}} - 1 \right) \left(\frac{\Pi_{t+1}}{\bar{\Pi}} \right) \right\}$$

- Euler equation for market capital:

$$q_t^M = \mathbb{E}_t \left\{ M_{t+1} \left[U_{m,t+1} \tfrac{R_{t+1}^K}{P_{t+1}} + q_{t+1}^M \left(1 - \delta(U_{m,t+1}) - \tfrac{\phi_{k_m}}{2} \left(\tfrac{I_{m,t+1}}{K_{m,t+1}} - \delta \right)^2 + \phi_{k_m} \left(\tfrac{I_{m,t+1}}{K_{m,t+1}} - \delta \right) \left(\tfrac{I_{m,t+1}}{K_{m,t+1}} \right) \right) \right] \right\}$$

- Optimality condition for market investment:

$$\frac{1}{q_t^M} = 1 - \phi_{k_m} \left(\frac{I_{m,t}}{K_{m,t}} - \delta \right)$$

- Dividends:

$$\frac{D_t^E}{P_t} = \frac{D_t}{P_t} - \nu\left(K_{m,t} - \frac{1}{R_t^R}K_{m,t+1}\right)$$

- Taylor rule:

$$r_t = \rho_r r_{t-1} + (1-\rho_r)\left[\bar{r} + \rho_\pi\left(\pi_t - \bar{\pi}\right) + \rho_y \Delta y_t\right]$$

with $x_t = \log X_t$ for a generic variable X_t, and where $\Delta y_t = y_t - y_{t-1}$.

- Euler equation for a zero-net supply nominal bond:

$$1 = R_t \mathbb{E}_t\left\{\frac{M_{t+1}}{\Pi_{t+1}}\right\}$$
$$1 = \beta\mathbb{E}_t\left\{\frac{a_{t+1}}{a_t}\left(\frac{U(C_{t+1},l_{t+1})}{U(C_t,l_t)}\right)^{\frac{1-\sigma}{\theta_v}-1}\frac{U_c(C_{t+1},l_{t+1})}{U_c(C_t,l_t)}\left(\frac{C_{m,t+1}}{C_{m,t}}\frac{C_t}{C_{t+1}}\right)^{b_1-1}\left(\frac{V_{t+1}^{1-\sigma}}{\mathbb{E}_t V_{t+1}^{1-\sigma}}\right)^{1-\frac{1}{\theta_v}}\frac{R_t}{\Pi_{t+1}}\right\}$$

- Definition of Markups:

$$\mu_t = (RMC_t)^{-1}$$

- Rotemberg cost definition:

$$\Phi_t = 1 + \frac{\phi_p}{2}\left(\frac{\Pi_t}{\bar{\Pi}} - 1\right)^2 Y_t$$

- Preference shock:

$$a_t = (1-\rho_a)\bar{a} + \rho_a a_{t-1} + \sigma_{t-1}^a \epsilon_t^a$$

- Preference volatility shock:

$$\sigma_t^a = (1-\rho_{\sigma_a})\bar{\sigma}_a + \rho_{\sigma_a}\sigma_{t-1}^a + \sigma^{\sigma_a}\epsilon_t^{\sigma_a}$$

- Labor-productivity shock:

$$Z_{m,t} = (1-\rho_{z_m})\bar{Z}_m + \rho_{z_m} Z_{m,t-1} - \bar{\sigma}_z \epsilon_t^z$$

where $\bar{Z}_m = 1$

- Aggregate TFP:

$$z_t^{norm} = \rho_{z^{norm}} z_{t-1}^{norm} + (1-\rho_{z^{norm}})z^{n\bar{o}rm} + \sigma_{t-1}^z \epsilon_t^z$$

- TFP volatility shocks:

$$\sigma_t^z = (1-\rho_{\sigma_z})\bar{\sigma}_z + \rho_{\sigma_z}\sigma_{t-1}^z + \sigma^{\sigma_z}\epsilon_t^{\sigma_z}$$

Parameterization

Table 4 below summarizes the parameterization of the model

TABLE 4: MODEL PARAMETERS

Calibrated Parameters	
Discount factor	$\beta = 0.994$
Intertemporal elasticity of substitution	$\psi = 0.95$
Risk aversion	$\gamma = 2$
Elasticity of substitution between market and home consumption	$b = 0.5$
Expenditure share on market on goods	$a_1 =$
Elasticity of substitution between total consumption and leisure	$\eta =$
Capital share production function	$\alpha =$
Capital depreciation rate	$\delta =$
Fixed production cost	$\Gamma =$
Investment adjustment cost	$\phi_k = 2$
Elasticity of substitution of intermediate goods	$\theta_\mu = 6$
Price adjustment cost	$\phi_p = 100$
Monetary policy inflation coefficient	$\rho_\pi = 1.5$
Monetary policy output coefficient	$\rho_y = 0.2$
Demand level shock, std. deviation	$\sigma^a =$
Demand level shock, persistence	$\rho_a =$
Demand volatility shock, std. deviation	$\sigma^{\sigma_a} =$
Demand volatility shock, persistence	$\rho_{\sigma_a} =$
TFP shock, std. deviation	$\sigma_z =$
TFP shock, persistence	$\rho_z =$

C Local Projections for Macroeconomic Variables

TBW