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Consumption and labor supply

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ABSTRACT

We present a new econometric model of aggregate demand and labor supply for the United States. We also analyze the allocation full wealth among time periods for households distinguished by a variety of demographic characteristics. The model is estimated using micro-level data from the *Consumer Expenditure Surveys* supplemented with price information obtained from the Consumer Price Index. An important feature of our approach is that aggregate demands and labor supply can be represented in closed form while accounting for the substantial heterogeneity in behavior that is found in household-level data. As a result, we are able to explain the patterns of aggregate demand and labor supply in the data despite using a parametrically parsimonious specification.

1. Introduction

The objective of this paper is to present a new econometric model of aggregate consumer behavior for the United States. The model allocates full wealth among time periods for households distinguished by demographic characteristics and determines the within-period demands for leisure, consumer goods, and services. An important feature of our approach is the development of a closed form representation of aggregate demand and labor supply that accounts for the heterogeneity in household behavior that is observed in micro-level data. Aggregate demand functions are important components of general equilibrium models that are used to analyze the macroeconomic consequences of a broad spectrum of public policies.

We combine expenditure data for over 150,000 households from the Consumer Expenditure Surveys (CEX) with price information from the Consumer Price Index (CPI) between 1980 and 2006. Following Slesnick (2002) and Kokoski et al. (1994), we exploit the fact that the prices faced by households vary across regions of the United States as well as across time periods. We use the CEX to construct quality-adjusted wages for individuals with different characteristics that also vary across regions and over time. In order to measure the value of leisure for individuals who are not employed, we impute the opportunity wages they face using the wages earned by employees.

Cross-sectional variation of prices and wages is considerable and provides an important source of information about patterns of consumption and labor supply. The demographic characteristics of households are also significant determinants of consumer expenditures and the demand for leisure. The final determinant of consumer behavior is the value of the time endowment for households. Part of this endowment is allocated to labor market activities and reduces the amount available for consumption in the form of leisure.

We employ a generalization of the translog indirect utility function introduced by Jorgenson et al. (1997) in modeling household demands for goods and leisure. This indirect utility function generates demand functions with rank two in the sense of Gorman (1981). The rank-extended translog indirect utility function proposed by Lewbel (2001) has Gorman rank three. We present empirical results for the original translog demand system as well as the rank-extended translog system and conclude that the rank three system more adequately represents consumer behavior although the differences are not large.

Our model of consumption and labor supply is based on two-stage budgeting and is most similar to the framework described and implemented by Blundell et al. (1994) for consumption goods alone. The first stage allocates full wealth, including assets and the value of the time endowment, among time periods using the standard Euler equation approach introduced by Hall (1978). Since the CEX does not provide annual panel data at the household level,

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we employ synthetic cohorts, introduced by Browning et al. (1985) and utilized, for example, by Attanasio et al. (1999), Blundell et al. (1994) and many others.

We introduce our model of consumer behavior in Section 2. We first consider the second stage of the model, which allocates full consumption among leisure, goods, and services. We subsequently present the first stage of the consumer model that describes the allocation of full wealth across time periods. In Section 3 we discuss data issues including the measurement of price and wage levels that show substantial variation across regions and over time. In Section 4 we present the estimation results for the rank-two and rank-three specifications of our second-stage model. We present estimates of price and income elasticities for goods and services, as well as leisure. We find that the wage elasticity of household labor supply is essentially zero, but the compensated elasticity is large and positive. Leisure and consumer services are income elastic, while capital services and nondurable goods are income inelastic. Perhaps most important, we find that the aggregate demands and labor supplies predicted by our model accurately replicate the patterns in the data despite the (comparatively) simple representation of household labor supply.

Finally, we estimate a model of the inter-temporal allocation of full consumption. We partition the sample of households into 17 cohorts based on the birth year of the head of the household. There are 27 time series observations from 1980 through 2006 for all but the oldest and youngest cohorts and we use these data to estimate the remaining unknown parameters of the Euler equation using methods that exploit the longitudinal features of the data.

2. Modeling consumption behavior

We assume that household consumption and labor supply are allocated in accord with two stage budgeting. In the first stage, full expenditure is allocated over time so as to maximize a lifetime utility function subject to a full wealth constraint. Conditional on the chosen level of full expenditure in each period, households allocate expenditures across consumption goods and leisure so as to maximize a within-period utility function.

To describe the second stage model in more detail, assume that households consume n consumption goods in addition to leisure. The within-period demand model for household k can be described using the following notation:

$\mathbf{x_k} = (x_{1k}, x_{2k}, \ldots, x_{nk}, \mathbf{R}_k)$ are the quantities of goods and leisure.

$\rho_\mathbf{k} = (\mathbf{p_k}, p_{Lk})$ are prices and wages faced by household k. These prices vary across geographic regions and over time.

$w_{ik} = p_{ik}x_{ik}/F_k$ is the expenditure share of good i for household k.

$\mathbf{w_k} = (w_{1k}, w_{2k}, \ldots, w_{nk}, w_{Rk})$ is the vector of expenditure shares for household k.

$\mathbf{A_k}$ is a vector of demographic characteristics of household k.

$F_k = \sum p_{ik}x_{ik} + p_{Lk}R_k$ is the full expenditure of household k where p_{Lk} is the wage rate and R_k is the quantity of leisure consumed.

In order to obtain a closed-form representation of aggregate demand and labor supply, we use a model of demand that is consistent with exact aggregation as originally defined by Gorman (1981). Specifically, we focus on models for which the aggregate demands are the sums of micro-level demand functions rather than the typical assumption that they are generated by a representative consumer. Exact aggregation is possible if the demand function for good i by household k is of the form:

$$x_{ik} = \sum_{j=1}^{J} b_{ij}(\rho)\psi_j(F_k).$$

Gorman showed that if demands are consistent with consumer rationality, the matrix $\{b_{ij}(\rho)\}$ has rank that is no larger than three.[1]

We assume that household preferences can be represented by a translog indirect utility function that generates demand functions of rank three. Lewbel (2001) has characterized such a utility function to be of the form:

$$(\ln V_k)^{-1} = \left[\alpha_0 + \ln\left(\frac{\rho_\mathbf{k}}{\mathbf{F_k}}\right)'\alpha_\mathbf{p} + \frac{1}{2}\ln\left(\frac{\rho_\mathbf{k}}{\mathbf{F_k}}\right)' B_{pp}\ln\left(\frac{\rho_\mathbf{k}}{\mathbf{F_k}}\right) + \ln\left(\frac{\rho_\mathbf{k}}{\mathbf{F_k}}\right)' B_{pA}\mathbf{A_k}\right]^{-1} - \ln\left(\frac{\rho_\mathbf{k}}{\mathbf{F_k}}\right)'\gamma_\mathbf{p} \quad (1)$$

where we assume $B_{pp} = B'_{pp}$, $i'B_{pA} = 0$, $i'B_{pp}i = 0$, $i'\alpha_\mathbf{p} = -1$ and $i'\gamma_\mathbf{p} = 0$.

To simplify notation, define $\ln G_k$ as:

$$\ln G_k = \alpha_0 + \ln\left(\frac{\rho_k}{\mathbf{F_k}}\right)'\alpha_\mathbf{p} + \frac{1}{2}\ln\left(\frac{\rho_k}{\mathbf{F_k}}\right)' B_{pp}\ln\left(\frac{\rho_k}{\mathbf{F_k}}\right) + \ln\left(\frac{\rho_k}{\mathbf{F_k}}\right)' B_{pA}\mathbf{A_k}. \quad (2)$$

Application of Roy's Identity to Eq. (1) yields budget shares of the form:

$$\mathbf{w_k} = \frac{1}{D(\rho_k)}\left(\alpha_\mathbf{p} + B_{pp}\ln\frac{\rho_k}{F_k} + B_{pA}\mathbf{A_k} + \gamma_\mathbf{p}[\ln G_k]^2\right) \quad (3)$$

where $D(\rho_\mathbf{k}) = -1 + i'B_{pp}\ln\rho_k$.

With demand functions of this form, aggregate budget shares, denoted by the vector $\mathbf{w}$, can be represented explicitly as functions of prices and summary statistics of the joint distribution of full expenditure and household attributes:

$$\mathbf{w} = \frac{\sum_k F_k\mathbf{w_k}}{\sum_k F_k} = \frac{1}{D(\rho)}\left[\alpha_\mathbf{p} + B_{pp}\ln\rho - i'B_{pp}\frac{\sum F_k\ln F_k}{\sum F_k} + B_{pA}\frac{\sum F_k\mathbf{A_k}}{F_k} + \gamma_\mathbf{p}\frac{\sum F_k(\ln G_k)^2}{\sum F_k}\right].$$

2.1. The inter-temporal allocation of consumption

In the first stage of the household model, full expenditure F_{kt} is allocated across time periods so as to maximize lifetime utility U_k for household k:

$$\max_{F_{kt}} U_k = E_t\left\{\sum_{t=1}^{T}(1+\delta)^{-(t-1)}\left[\frac{V_{kt}^{(1-\sigma)}}{(1-\sigma)}\right]\right\} \quad (4)$$

subject to:

$$\sum_{t=1}^{T}(1+r_t)^{-(t-1)}F_{kt} \le W_k$$

where r_t is the nominal interest rate, σ is an inter-temporal curvature parameter, and δ is the subjective rate of time preference. We expect δ to be between zero and one and the within-period utility function is logarithmic if σ is equal to one.

The first order conditions for this optimization yield Euler equations of the form:

$$(V_{kt})^{-\sigma}\left[\frac{\partial V_{kt}}{\partial F_{kt}}\right] = E_t\left[(V_{k,t+1})^{-\sigma}\left[\frac{\partial V_{k,t+1}}{\partial F_{k,t+1}}\right]\frac{(1+r_{t+1})}{(1+\delta)}\right]. \quad (5)$$

[1] See Blundell and Stoker (2005) for further discussion.

If the random variable η_{kt} embodies expectational errors for household k at time t, Eq. (5) becomes:

$$(V_{kt})^{-\sigma}\left[\frac{\partial V_{kt}}{\partial F_{kt}}\right] = \left[(V_{k,t+1})^{-\sigma}\left[\frac{\partial V_{k,t+1}}{\partial F_{k,t+1}}\right]\frac{(1+r_{t+1})}{(1+\delta)}\right]\eta_{k,t+1}. \quad (6)$$

We can simplify this equation by noting that, for the rank three specification of the indirect utility function given in Eq. (1), we obtain:

$$\frac{\partial V_{kt}}{\partial F_{kt}} = \frac{V_{kt}}{F_{kt}}(-D(\rho_{kt}))[1-(\gamma_{\mathbf{p}}' \ln \rho_{kt})^{*}G_{kt}]^{-2}.$$

The last term in the square bracket is approximately equal to one in the data, so that taking logs of both sides of Eq. (6) yields:

$$\Delta \ln F_{k,t+1} = (1-\sigma)\Delta \ln V_{k,t+1} + \Delta \ln(-D(\rho_{k,t+1})) + \ln(1+r_{t+1}) - \ln(1+\delta) + \ln \eta_{kt}. \quad (7)$$

Eq. (7) serves as the estimating equation for σ and the subjective rate of time preference δ.

3. Data issues

3.1. The CEX sample

In the United States, the only comprehensive sources of information on expenditure and labor supply are the CEX published by the Bureau of Labor Statistics. These surveys are representative national samples that are conducted for the purpose of computing the weights in the CPI. The surveys were administered approximately every ten years until 1980 when they were given every year. Detailed information on labor supply is provided only after 1980 and, as a result, we use the sample that covers the period from 1980 through 2006. Expenditures are recorded on a quarterly basis and our sample sizes range from between 4000 and 8000 households per quarter. To avoid issues related to the seasonality of expenditures, we use only the set of households that were interviewed in the second quarter of each year.[2]

In order to obtain a comprehensive measure of consumption, we modify the total expenditure variable reported in the surveys by deleting gifts and cash contributions as well as pensions, retirement contributions, and Social Security payments. Outlays on owner occupied housing such as mortgage interest payments, insurance, and the like are replaced with households' estimates of the rental equivalents of their homes. Durable purchases are replaced with estimates of the services received from the stocks of goods held by households.[3] After these adjustments, our estimate of total expenditure is the sum of spending on nondurables and services (a frequently used measure of consumption) plus the service flows from consumer durables and owner-occupied housing.

3.2. Measuring price levels in the US

The CEX records the expenditures on hundreds of items, but provides no information on the prices paid which makes it necessary to link the surveys with price data from alternative sources. While the BLS provides time series of price indexes for different cities and regions, they do not publish information on price levels. Kokoski et al. (1994) (KCM) use the 1988 and 1989 CPI database to estimate the prices of goods and services in 44 urban areas. We use their estimates of prices for rental housing, owner occupied housing, food at home, food away from home, alcohol and tobacco, household fuels (electricity and piped natural gas), gasoline and motor oil, household furnishings, apparel, new vehicles, professional medical services, and entertainment.[4] Given price levels for 1988 and 1989, prices both before and after this period are extrapolated using price indexes published by the BLS. Most of these indexes cover the period from December 1977 to the present at either monthly or bimonthly frequencies depending on the year and the commodity group.[5]

These prices are linked to the expenditure data in the CEX. Although KCM provide estimates of prices for 44 urban areas across the US, the publicly available CEX data do not report households' cities of residence in an effort to preserve the confidentiality of survey participants. This necessitates aggregation across urban areas to obtain prices for the four major Census regions: the Northeast, Midwest, South and West. Because the BLS does not collect nonurban price information, rural households are assumed to face the prices of Class D-sized urban areas.[6]

3.3. Measuring wages in efficiency units

The primitive observational unit in the CEX is a "consumer unit", and expenditures are aggregated over all members. We choose to model labor supply at the same level of aggregation by assuming that male and female leisure are perfect substitutes when measured in quality-adjusted units. The price of leisure (per efficiency unit) is estimated using a wage equation defined over "full time" workers, i.e. those who work more than forty weeks per year and at least thirty hours per week. The wage equation for worker i is given by:

$$\ln P_{Li} = \sum_j \beta_j^z z_{ji} + \sum_j \beta_j^s (S_i^* z_{ji}) + \sum_j \beta_j^{nw}(NW_i^* z_{ji}) + \sum_l \beta_l^g g_{li} + \varepsilon_{it} \quad (8)$$

where

p_{Li} — the wage of worker i.

z_i — a vector of demographic characteristics that includes the age, age squared, years of education, and years of education squared of worker i.

S_i — a dummy variable indicating whether the worker is female.

NW_i — a dummy variable indicating whether the worker is nonwhite.

g_i — a vector of region-year dummy variables.

The wage equation is estimated using the CEX from 1980 through 2006 using the usual sample selection correction, and the quality-adjusted wage for a worker in region-year s is given by $p_L^s = \exp(\hat{\beta}_s^g)$. The parameter estimates (excluding the region-year effects) are presented in Appendix Table A.1.

In Fig. 1a we present our estimates of quality-adjusted hourly wages in the urban Northeast, Midwest, South, West as well

[2] Surveys are designed to be representative only at a quarterly frequency. We use the second quarter to avoid seasonality of spending associated with the summer months and holiday spending at the end of the calendar year.

[3] The methods used to compute the rental equivalent of owner occupied housing and the service flows from consumer durables are described in Slesnick (2001).

[4] In 1988 and 1989 these items constituted approximately 75% of all expenditures.

[5] A detailed description of this procedure can be found in Slesnick (2002).

[6] These areas correspond to nonmetropolitan urban areas and are cities with less than 50,000 persons. Examples of cities of this size include Yuma, Arizona in the West, Fort Dodge, Iowa in the Midwest, Augusta, Maine in the Northeast and Cleveland, Tennessee in the South.

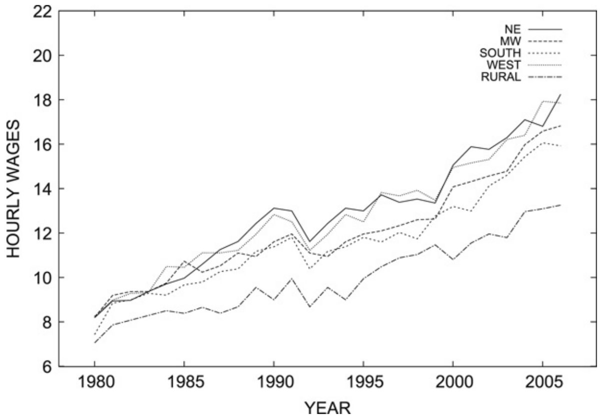

Fig. 1a. Regional wages (current dollars).

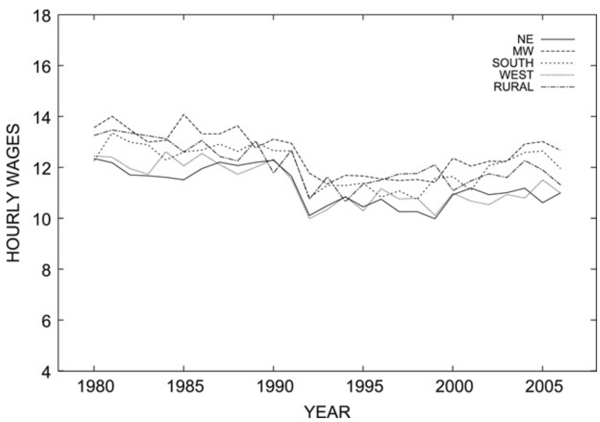

Fig. 1b. Regional real wages (NE 1989 dollars).

as rural areas from 1980 through 2006. The reference worker, whose quality is normalized to one, is a white male, age 40, with 13 years of education. The levels and trends of the wages are generally consistent with expectations; the highest wages are in the Northeast and the West and the lowest are in rural areas. Nominal wages increase over time with the highest growth rate occurring in the Northeast and the lowest is in rural areas. Perhaps more surprising is the finding that real wages, shown in Fig. 1b, have decreased over the sample period and exhibit substantially less variation across regions. This suggests that more accurate adjustments for differences in the cost of living across geographic regions reduce the between-region wage dispersion to a large degree.

3.4. Measuring quality-adjusted household leisure

For workers, estimates of the quantity of leisure consumed are easily obtained. The earnings of individual m in household k at time t are:

$$E_{kt}^{m} = p_{Lt} q_{kt}^{m} H_{kt}^{m},$$

where p_{Lt} is the wage at time t per efficiency unit, q_{kt}^{m} is the quality index of the worker, and H_{kt}^{m} is the observed hours of work. With observations on wages and the hours worked, the quality index for worker m is:

$$q_{kt}^{m} = \frac{E_{kt}^{m}}{p_{Lt} H_{kt}^{m}}.$$

If the daily time endowment is 14 h, the household's time endowment measured in efficiency units is $T_{kt}^{m} = q_{kt}^{m} * (14)$ and leisure consumption is $R_{kt}^{m} = q_{kt}^{m}(14 - H_{kt}^{m})$.

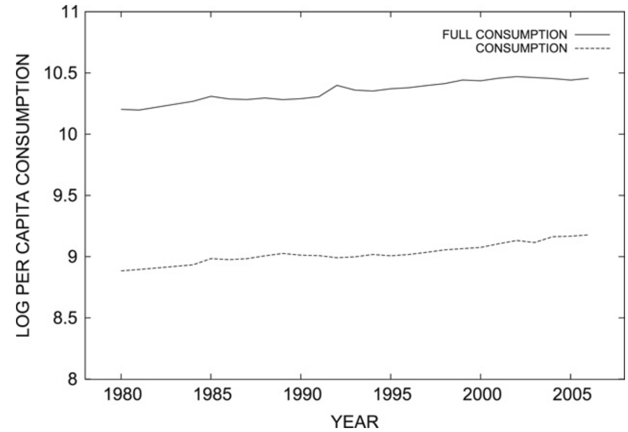

Fig. 2a. Log consumption per capita (constant dollars).

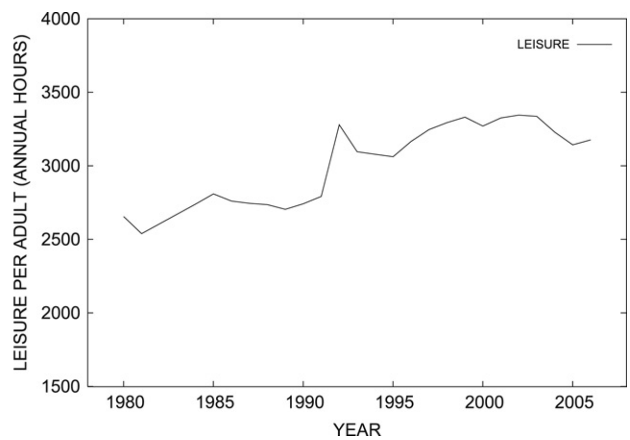

Fig. 2b. Quality-adjusted leisure per adult.

For nonworkers, we impute a nominal wage for individual m in household k, $\hat{p}_{Lkt}^{m}$, using the fitted values of a wage equation similar to Eq. (8). The estimated quality adjustment for nonworkers is:

$$\hat{q}_{kt}^{m} = \frac{\hat{p}_{Lkt}^{m}}{p_{Lt}},$$

and the individual's leisure consumption is calculated as $R_{kt}^{m} = \hat{q}_{kt}^{m} * (14)$. Given estimates of leisure for each adult in the household, full expenditure for household k is computed as:

$$F_{kt} = p_{Lt} R_{kt} + \sum_{i} p_{ik} x_{ik}$$

where $R_{kt} = \sum_{m} R_{kt}^{m}$ is total household leisure computed as the sum over all adult members.

In Fig. 2a we present tabulations of per capita full consumption (goods and household leisure) as well as per capita consumption (goods only). For both series, expenditures are deflated by price and wage indexes that vary over time and across regions. Over the period from 1980 through 2006, per capita consumption grew at an average annual rate of 1.1% per year compared to 1.0% per year for per capita full consumption. Fig. 2b shows the average level of quality-adjusted leisure consumed per adult. The average annual hours increased by approximately 18% over the 26 years from 2656 in 1980 to 3177 in 2006. Fig. 2c shows that the inclusion of household leisure has the effect of lowering the dispersion in consumption in each year. The variance of log per capita full consumption is approximately 25% lower than the variance of log per capita consumption. The trends of the two series, however, are similar.