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**Marketizing U.S. Production in the Post-War Era:
Implications for Estimating CPI Bias and Real Income
from a Complete-Household-Demand System**

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Marketizing U.S. Production in the Post-War Era: Implications for Estimating CPI Bias and Real Income from a Complete-Household-Demand System

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Abstract

This paper applies production theory to define a new set of inputs for U.S. households for the post-war II period, tests the new inputs to see if they support a complete household-demand system, and reports a new social cost-of-living index. The data support a demand system with nine major input categories and yield plausible price, income, and translating-variable effects. Women's and men's housework are complements, but other input categories are substitutes for women's housework. Some changes in the demand are associated with household technology and demographics. My social cost-of-living index rises at an approximately 1.4 percent per year slower over the post-war era than the implicit price deflator.

Key Words: Complete-demand system, household production, social cost of living index, post-war II.

Marketizing U.S. Production in the Post-War Era: Implications for Estimating CPI Bias and Real Income from a Complete-Household-Demand System

During the post-World War II era, the U.S. has undergone relatively rapid economic growth and major mobilization of resources for market activities. During 1948 to 1996, Jorgenson and Stiorh (1999) report that U.S. aggregate output grew at 3.4 percent per year which was high relative to the 2.1 percent growth during the previous 20 year period, 1929-1948 (Christensen and Jorgenson 1970). During the post-war period, growth in labor input accounted for 32 percent of the total growth or 1.1 percent per year. The growth in market labor input was made possible by a growing population and major increase in market work by women and reduction in their housework. These adjustments increased households' demand for market-substitutes for women's housework. Work, school, religious, and social activities are now synchronized to the "clock," one indication of the rising real value of human time. Hence, during the post-war period the U.S. has experienced marketization of women's work and production and commodificaton of human time (Freeman and Schettkar 2002).

Although the U.S. household sector has clearly undergone major organizational changes during the post-war era, an in depth examination of these adjustments has not been presented. Jorgenson and Stiroh (1999), however, have shown that the U.S. household sector responded in a predictable way to the dramatic decline in the relative price of services of information technologies, including computers.[1] In this study, I apply a generalized version of Becker's productive household model, i.e., inputs are used to produce abstract commodities that are the source of utility to households. However, given that the commodities/outputs are unobservable, I follow Jorgenson and Stiroh and systematically apply production theory to the inputs going into household production and focus the discussion on the demand for inputs and not on

commodities. That is, labor and capital services and intermediate goods are inputs into household

production, and purchased capital goods or investments in consumer durables are not (Jorgenson

and Stiroh 1999). The labor input is housework and leisure of a household's members. Capital

services are proportional to the stock of consumer assets, but aggregation requires weighting the

stocks by rental prices rather than acquisition prices for assets. The rental price for each asset

incorporates the rate of return, the depreciation rate, and the rate of decline in the acquisition

price. Hence, household demand housework, leisure, purchased nondurable consumption goods

and services and the services of household durable goods (Becker 1965, Michael and Becker

1976, Gronau 1977, Committee on National Statistics 2000).

The Bureau of Labor Statistics (BLS) and the Bureau of Economic Analysis (BEA),

however, have traditionally constructed the consumer price index (CPI) and implicit price

deflator (IPD) for personal consumption expenditures using prices for *consumer purchased*

goods (e.g., see Boskin *et al.* 1998; Hausman 1996; Diewert 1976).[2] Because these price indexes

use the set of prices including consumer purchase of durables, e.g., automobiles, motor homes,

refrigerators, dishwashers, ranges, televisions, stereo systems, rather than their rental price and

exclude the price of women's and men's housework (and leisure), they are not a *cost-of-living*

index. Given that human time has an opportunity cost roughly equal to the market wage,

household total expenditures are increased dramatically (by about two-thirds) when one shifts

from a cash-expenditure to a full-expenditure budget constraint.[3]

The objective of this paper is to apply production theory systematically to define a new

set of inputs for household production, to test the new input measures to see if they support a

complete household-demand system, and under a plausible set of assumption, compute a social

cost-of-living index using the expenditure function associated with the estimated parameters of a

complete household-demand system. I show that during the post-World War II period, the price of women's and men's housework rose relative to the prices of all inputs in household production (Schultz 1972, Council of Economic Advisors 2001); and for women's housework, the rise was most dramatic over 1948 to 1980 and minimal thereafter. Results from the estimated demand system include *women's and men's housework are shown to be complements rather than substitutes*, *but other major input categories are substitutes for women's housework*. Some of the changes in the demand for women's housework and other inputs are associated with the sizeable change in household technology and demographics, including a declining share of households living in non-metropolitan areas, over the post war era. Under a plausible set of assumption, I show that including the price of women's and men's housework and leisure, price of services of consumer durables rather than price of new durables, and substitution effects among major input components of demand results in the social cost-of-living index rising at an *approximately 1.4 percent per year slower over the post-war era* than the IPD of the BEA. Hence, conventional estimates of the rate of growth of social welfare per capita have been biased downward significantly over the post war era.

I begin the paper with a presentation of a summary of information on time allocation of U.S. women and men. Section two and three present the economic model of consumer demand and the econometric model, data, and variables, respectively. Section four presents the empirical results and their interpretation, and the final section presents conclusions and implications.

Background on Time Allocation

Time allocation of U.S. men and women who are not in school has changed significantly over the post World War II period. Legal and social restrictions on married-women's work in the market, i.e., "self-protection" legislation, existed from roughly 1850 to 1950 (Goldin 1990).

They greatly reduced the effective supply of female labor to the U.S. labor market. Starting about 1950, job opportunities for married women, including regular part-time work, opened up. For married women with children under age 6, the labor force participation rate was under 10 percent in 1948, but since then, it has risen, especially after 1970, to the rate for all women of about 60 percent. This represents a dramatic increase in the supply of female labor in the market.

Bryant (1996) presents the only consistent early comparisons of women's housework. He estimates that in the mid-1960s the average amount of time U.S. *married women* allocated to housework--- time allocated primarily to food preparation and cleanup, house and garden care, care of clothing and linens, care of family members, and marketing and management--- was 44.2 hours per week (6.31 hours per day). This was a reduction from 51.5 hours per week in 1925 (7.35 hours per day), and all major categories of housework declined, except for management and marketing which increased by 20 percent. Juster and Stafford (1991) report that the average amount of housework of *U.S. women*, 25-64 years of age, was 41.8 hours per week in 1965 (6 hours per day), and it decreased to 30.5 hours (4.4 hours per day) in 1981 or by 31.5 percent.[4] Average hours of market work, including commuting, increased from 20.5 hours per week in 1965 to 25.9 hours in 1981. Hence, their data show women's hours of leisure time rose over this period.

For men, fewer estimates of housework exist. Juster and Stafford report that in 1965 housework for men 25 to 64 years averaged 11.5 hours per week (1.64 hours per day), and it increased to 12.8 hours per week (1.83 hours per day) in 1981. Men's average weekly hours of market work, including commuting, was 56.2 hours in 1965 and declined to 47.5 hours in 1981.

Juster and Stafford's data show that men's housework relative to women's housework and men's leisure increased over 1965 to 1981.

Robinson and Godbey (1999, pp. 329) provide the most extensive data starting in 1965 on housework for U.S. women and men, age 18-64 years and for 65 and older. Focusing on women 18-64 year old, they report average weekly hours of housework of 40.3 (5.76 hours per day) in 1965, 32.9 (4.70) in 1975, 30.7 (4.39) in 1985, and 27.4 (3.91) in 1995.[5] In contrast to women, their data for men 18-64 years show an increase in average weekly hours of housework over time: 11.3 (1.61 hours per day) in 1965, 12.3 (1.76) in 1975, 15.7 (2.24) in 1985 and 15.6 (2.23) in 1995. Thus, for women the most dramatic change was the 7.4 hours per week or 20 percent reduction from 1965 to 1975, which is also a time period when the number of children per adult was declining steadily and dramatically (see figure 1). For men, the rate of change is positive and but slow. In conclusion, these prior studies suggest that the amount of women's household work has declined, especially over 1965 to 1975, and hours of housework of men have generally risen since 1965.

Now firms use a diverse set of skilled women's (and men's) labor and other inputs and economies of scale to produce and market consumer and producer goods, services, and durables. Services of new consumer durable and other consumer goods and services substitute largely for women's housework and reduce the drudgery of doing the laundry and ironing, carrying water, and spring house cleaning, and speeded up preparation of meals and many other things (Bryant 1986).

Major changes in households include less time allocated by women to preparing meals at home and clean up and more meals consumed away from home. Workday lunches are purchased and eaten at school and work, and weekend dinners are eaten in restaurants. When meals are at

home, ready-to-eat food is frequently purchased at fast-food restaurants, grocery delis, or other restaurants (take-out) and taken home to be eaten. When meals are prepared at home, microwave ovens with timers and electric and gas ranges with thermostatic controlled burners and ovens speed cooking and give control over the temperature and lead to a higher quality product. These appliances are technically advanced relative to the coal, wood, kerosene, and LP gas burning cooking stoves of the late 40s (Bryant 1986).

Fifty years ago married women allocated significant time to making and caring for clothing and linens, but new technology has been substituted for this work. "To make" versus "to buy" was an important decision in 1948, but today, ready-to-wear clothing are the norm, which is a major saver of women's housework, and hand-made is the exception. In the late forties, U.S. households used relatively primitive motorized clothes-washing machines with wringers to do the laundry. Doing the laundry involved handling heavy wet clothing, including carrying them outside in baskets to be hung on an elevated clothesline to dry naturally—in the open air with perhaps the aid of energy from the sun. Today, almost all households have an automatic clothes washer and dryer, and wash-and-wear or non-wrinkle (and hence, non-iron) fabrics are available, and the "casual dress" for work has become acceptable dress. Doing the laundry, which remains largely women's work (Robinson and Godbey 1999), requires little time and only modest human effort (Bryant 1986). Mechanical and electric power have been substituted for women's time and effort. Also, automatic clothes washers and dryers are continually being introduced with new and broader range of water and fabric settings. Hence, the quality of these services continues to change and improve with the introduction of new goods. Modern dishwashers are both a timesaver and improve the quality of the dishwashing services by washing and sanitizing at the same time.

Leisure time or time allocated primarily to leisure has a traditional meaning of pleasureful time (Robinson and Godbey 1999; Committee on National Statistics 2000, pp. 15-18; Gronau 1977).[6] During the past half-century, the capital intensity of leisure time activities has increased, too. In the 1950s individuals engaged in time-intensive leisure activities--active conversation with family members, relatives, and friends; reading books; playing games; participating in social organizations, and less than 10 percent of households had a television. Today, however, approximately 50 percent of leisure time is allocated to television viewing (Robinson and Godbey 1999). Furthermore, major technical advances in television sets have occurred—from small black and white TV sets receiving an average of 3 to 4 stations in the 1950s and 1960s to today where household's consume TV services on large-screen color TVs, frequently connected to cable or satellite reception and VCRs and providing a large number and range of viewing opportunities. Most have remote control electronic devices for changing channels and sound volume without leaving an easy chair compared to the 1950s and 1960s when these changes had to be made manually by an individual walking to the TV and turning a knob. Hence, technology and services of consumer-durable goods have also been substituted for human time in leisure-time activities.

The Economic Model: Consumer Demand for New and Other Goods

Consider consumer welfare in a market economy where new goods are being introduced and the quality of old goods is changing regularly (Hausman 1996; Boskin *et al.* 1998). In an inventive and innovative economy, ignoring prices of goods when new and then after they have been on the market for several years introducing them into the set of prices used to compute the cost-of-living index leads to overestimates of the increase in the true cost-of-living and underestimates of the increase in social welfare. The virtual (or implicit) price p_1^V for a new (or

household supplied) good x_1 at which the consumer optimally and voluntarily chooses the available level X_1, which might be zero, is

$$X_1 = x_1^c(U_0, p_1^V, p_2). \tag{1}$$

That is, the virtual price is an implicit function of the zero quantity of new goods (or the household supplied quantity of housework, services of consumer durable), prices of the market-supplied goods and services, and utility U_0. Given the virtual price p_1^V, the Hicksian demand functions with zero quantity available (x_2^{Rc}) equals the Hicksian-demand functions without free availability (x_2^c):

$$0 = x_2^{Rc}(U_0, p_1, p_2, X_1) = x_2^c(U_0, p_1^V, p_2). \tag{2}$$

In particular, Hausman (1996) examines the impact of new goods (i.e., breakfast cereals) on consumer welfare. Given the demand function, Hausman solves implicitly for the virtual price that causes the demand for the new good to be equal to zero in the pre-introduction period. Based on an example of a new cereal brand, he finds that the CPI may be overstated for cereal by about 25 percent if the new cereal brands are neglected. Hausman's methodology is new and innovative, but Huffman and Johnson (1999) were one of the first to apply it to estimating demand systems, cost of living indexes, and welfare change.

Virtual Prices and Consumer Demand

The virtual-price demand system presented below is developed using a modification of the AIDS cost function and draws on the previous work by Deaton and Muellbauer (1980b) and Huffman and Johnson (1999).[7] The virtual-price form of the AIDS-cost function in logarithmic form is:

$$\log C(U_0, p_1^V, p_2) = (1 - U_0)\log[a(p_1^V, p_2)] + U_0 \log[b(p_1^V, p_2)] \tag{3}$$

where $C(U_0, p_1^V, p_2)$ is the cost function, p_2 is a *h*-vector of market prices, p_1^V is a *k*-vector of

virtual prices (prices of rationed goods), where $h + k = n$, and U_0 is the utility level. For

$a(p_1^V, p_2)$ and $b(p_1^V, p_2)$ specific functional forms are given, which are positive, linearly

homogeneous, and concave in prices. Following Deaton and Muellbauer (1980b), a translog

flexible-functional form is chosen for $a(p_1^V, p_2)$ which depends both on market and virtual

prices. That is,

$$
\begin{aligned}
\log a(p_1^V, p_2) = \alpha_0 &+ \sum_{j=1}^{k} \alpha_{Vj} \log p_{1j}^V + \sum_{j=k+1}^{n} \alpha_j \log p_{2j} \\
&+ 1/2 [\sum_{i=1}^{k} \sum_{j=1}^{k} \gamma_{ViVj}^* \log p_{1i}^V \log p_{1j}^V \\
&+ \sum_{i=k+1}^{n} \sum_{j=k+1}^{n} \gamma_{ij}^* \log p_{2i} \log p_{2j} \\
&+ \sum_{i=1}^{k} \sum_{j=k+1}^{n} \gamma_{Vij}^* \log p_{1i}^V \log p_{2j} \\
&+ \sum_{i=k+1}^{n} \sum_{j=1}^{k} \gamma_{iVj}^* \log p_{2i} \log p_{1j}^V].
\end{aligned}
\tag{4}
$$

Compared to the standard AIDS model, the linear portion here contains an extra term,

$\sum_{j=1}^{k} \alpha_{Vj} \log p_{1j}^V$, involving virtual prices, and the quadratic part includes extra cross-product terms.

The function $b(p_1^V, p_2)$ is defined as,

$$
\log b(p_1^V, p_2) = \log a(p_1^V, p_2) + \prod_{j=1}^{k} p_{1j}^{V \beta_j^V} \prod_{j=k+1}^{n} p_{2j}^{\beta_j}.
\tag{5}
$$

Substituting the expressions for $a(p_1^V, p_2)$ and $b(p_1^V, p_2)$ into the cost function (3) and applying

Shepard's lemma yields the budget/expenditure shares (Deaton and Muellbauer 1980a). Note

that these shares are derived from the virtual-cost function (3). Therefore, they are themselves

conditional on the vector of virtual prices, in addition to being functions of market prices and utility. Substituting the expression for utility from the cost function into the virtual-share equations gives,

$$w_i \big|_{p_1^V} = \alpha_i + \sum_{j=1}^{k} \gamma_{iVj} \log p_{1j}^V + \sum_{j=k+1}^{n} \gamma_{ij} \log p_{2j} + \beta_i \log[I^V / a(p_1^V, p_2)], \quad \text{for } i=1 \text{ to } n \qquad (6)$$

where $\gamma_{ij} = 1/2(\gamma_{ij}^* + \gamma_{ji}^*)$, and $\gamma_{iVj} = 1/2(\gamma_{ViVj}^* + \gamma_{VjVi}^*)$. If $\log a(p_1^V, p_2)$ is replaced by the Stone

price index $\log P(p_1^V, p_2) = \sum_{l=1}^{k} w_l \log p_{1l}^V + \sum_{j=k+1}^{n} w_j \log p_{2j}$, the virtual-share equations become

linear, i.e.,

$$w_i \big|_{p_1^V} = \alpha_i + \sum_{j=1}^{k} \gamma_{iVj} \log p_{1j}^V + \sum_{j=k+1}^{n} \gamma_{ij} \log p_{2j} + \beta_i \log[I^V / P(p_1^V, p_2)], \quad \text{for } i=1 \text{ to } n. \qquad (7)$$

Qualitative demographic and other "translating" variables are introduced into the demand systems to incorporate adult-equivalency effects associated with the age, race, and location (e.g., metropolitan versus non-metropolitan) distribution of the population:

$$w_i \big|_{p_1^V} = \alpha_i^{**} + \sum_{j=1}^{k} \gamma_{iVj} \log p_{1j}^V + \sum_{j=k+1}^{n} \gamma_{ij} \log p_{2j} + \beta_i \log[I^V / P(p_1^V, p_2)], \qquad (8)$$

where $\alpha_i^{**} = \alpha_{i0} + \sum_{s=1}^{S} \delta_{is} D_s$, and D_s are the translating variables.

The restrictions on the parameters assuming the theoretical properties for utility

maximization are—homogeneity $\sum_{j=1}^{k} \gamma_{iVj} + \sum_{j=k+1}^{n} \gamma_{ij} = 0 \text{ for } \forall i;$ symmetry $\gamma_{iVj} = \gamma_{jVi}$ and

$\gamma_{ij} = \gamma_{ji}$; and adding up $\sum_{i=1}^{n} \alpha_i^{**} = 1, \sum_{i=1}^{n} \delta_{is} = 0, \sum_{i=1}^{k} \gamma_{iVj} + \sum_{i=k+1}^{n} \gamma_{ij} = 0 \text{ for } \forall j,$ and $\sum_{i=1}^{n} \beta_i = 0.$

Cost-of-Living Indexes

The social cost-of-living index is the relative cost of reaching a given standard of living for two different time periods. The expenditure/cost function associated with a complete household demand system can be used to construct a social cost-of-living index. The most commonly used measure of cost-of- living, however, is the U.S. CPI (Boskin *et al.*1998; Diewert 1976), which is essentially a Laspeyres price index—$L(p^1, p^0)= 3\,p_1x_0/3\,p_0x_0 = 3\,p_1x_0/I_0$, where p_0 and p_1 are the prices under the two different time periods, and x_0 is the quantity for the base period. The Laspeyres price index gives an upward biased estimate of the cost-of-living, because in keeping constant weights for the base-period basket of goods as relative prices changed, it does not account for substitution among commodities (Boskin *et al.* 1998; Deaton and Muellbauer 1980a). In short, the CPI is a relatively crude instrument for measuring the impact of the introduction of new goods on individual welfare. The IIPD of the BEA is somewhat better than the CPI for long-term comparisons because it is an superlative price index, and the BEA makes regular revisions backward and forward associated with new information on quality change and introduction of new goods. The CPI is never revised backward; new procedures only go forward.

The true-cost-of living index invokes the theory of consumer demand. It is derived from the consumer expenditure function as the ratio of the minimum expenditures in two different time periods necessary to maintain a given utility level (as opposed to a constant basket of goods as in the Laspeyres price index). The base-period-weighted true-cost-of-living index is

$$P(p^0, p^1, U^0) = C(U^0, p^1)/ C(U^0, p^0), \tag{9}$$

where U^0, the base utility level, is equal to $\log [I^{V0}/a(p^0)]/\log [b(p^0)/a(p^0)]$, p^0 is a vector of market and virtual prices for the base period, and p^1 is a vector of market prices for the current period.

The true cost-of-living index can be calculated from the cost/expenditure function $C(U, p)$. From the estimated complete system of demand equations, I can find the cost function. Using the estimated parameters from the virtual AIDS model, the indirect utilities can be derived from the functional forms in equations (4) and (5) and, finally, the virtual cost-of-living indices from equation (9). The cost-of-living indices show the impacts of the introduction of new goods or quality change in "old goods" between the base and current period.

With the estimated coefficients from the virtual AIDS and the standard AIDS, I calculate indirect utility. The compensating variation given by the difference in cost functions or $CV=C(p^1, U^0)-C(p^0, U^0)$ for each individual/household can be evaluated directly. Positive differences indicate that the individual/household experienced a welfare loss as a result of the introduction of new goods. Finally, the change in real total income/expenditure can be used to show the total welfare change during a period of introduction of new goods or quality change in old goods resulting from private and public R&D.

The Econometric Model, Data and Variables

A brief discussion of the econometric model, data, and results follows.

The Econometric Model

The empirical specification of the AIDS model to be estimated is derived from equation (8), including symmetry, homogeneity, and adding-up restrictions, and presented in equation (10):

$$w_{it} \mid_{p_1^V} = \alpha_{i0} + \sum_{s=1}^{S} \delta_{is} D_{st} + \sum_{j=1}^{k} \gamma_{iVj} \log p_{1jt}^V + \sum_{j=k+1}^{n} \gamma_{ij} \log p_{2jt} + \beta_i \log[I_t^V / P(p_{1t}^V, p_{2t})] + \phi_i t + u_{it}, (10)$$

where α_{i0} is a time-invariant unobserved country-specific effect for input i, $\phi_i t$ represent the effects of time trend on input i, ε_{it} is a random disturbance term for input i and year t, and $i = 1$, ..., n denotes the input categories, and $t = 1, ..., T$ denotes the years (Wooldridge 2002, p. 251-258). With n-expenditure shares being endogenous and expenditure shares summing to one, one of the share equations can be deleted. Its parameters can be recovered from the other (n-1) estimated equations and the parameter restriction on the AIDS demand system.[8]

Equation (10) has two random unobserved terms---α_{i0} and ε_{it}. Furthermore, α_{i0} may be correlated with the other regressors and ε_{it}, and if the system were estimated in level form, this would in principle bias all the estimated coefficients. The additive disturbance terms u_{it} in equations (10) satisfy the usual stochastic assumptions (having a zero mean, fixed variance, first-order autoregressive process over time, and contemporaneous correlation across share equations). To get rid of the unobserved country-specific heterogeneity in each demand equation and to fully accommodate the time-series properties of the demand system, the (n-1) expenditure-share equations are treated as a system of first-order difference equations (i.e., ρ, the autocorrelation coefficient in each equation, is one) with a commodity-specific constant term (the ϕ_i in equation (10)). After removing the unobserved country-specific effects from each demand equation and transforming the disturbance term in the difference equations, the model is almost certainly covariance stationary (see Wooldridge 2002; Enders 1995, pp. 216-224; and Berndt and Savin 1975).[9]

The (n-1) demand equations can be configured as a stacked system of difference equations having the form of the seemingly-unrelated-regression model with contemporaneous cross-equation correlation of disturbances (Greene 2003, pp. 340-350). The feasible generalized least squares estimator is consistent, asymptotically efficient, and asymptotically equivalent to

the maximum likelihood estimator (Barten 1969). The latter results are invariant to the equation dropped or residually computed to accommodate the singularity of the error covariance matrix. The share equation for the n-th commodity group will be deleted in this application, and its parameters will be recovered using the adding up restrictions. The estimation is conducted using the ISUR procedure in SAS 8.02.

The Data

Econometrically, I am limited on the total number of major input categories or parameters that can be estimated in a complete household-demand system, but the formation of groups is somewhat arbitrary. I am interested in the extent to which capital services and purchased consumer goods and services substitute for women's housework and want to base that on econometric estimates. I can use superlative index numbers to aggregate components within major groups which will permit substitution effects.

The major types of products for personal consumer expenditures in the National Income and Product Accounts are: durable goods (motor vehicles and parts, furniture and household equipment, and other durable good), nondurable goods (food, clothing and shoes, fuel, and other nondurables), and services (housing, household operation, transportation, medical care, recreation, and other services). See the U.S. Department of Commerce. Guided by production theory, objectives of this study, and limits on the total number of parameters that can be estimated, I define nine major input groups: (i) women's housework, (ii) men's housework, (iii) food-at-home, (iv) purchased housework-substitute services (domestic services, laundry and dry-cleaning services, and food away from home), (v) housing services (for owner occupied and rental), (vi) services of household appliances (including imputed services from computers and furnishing owned and household utilities), (vii) transportation services (imputed services of

transportation capital owned, purchased transportation services, and fuel for transportation), (viii) recreation services (imputed services of recreation capital owned and recreation services purchased), and (ix) other goods and services (men's and women's leisure, medical services, and other). In this study, the "new goods" are women's and men's housework and leisure and the imputed services of consumer durables replace purchases of consumer durable goods. However, I use current and constant dollar consumer expenditures components on nondurable goods and services directly from the National Income and Production Accounts (U.S. Dept. of Commerce).

Each individual age 16 and older that is not in school is assumed to allocate his/her time across housework, market work, and leisure. Time allocated to sleep, personal care, and eating (i.e. personal care) are not included in allocate-able time and are assumed not to respond to prices and income (see Robinson and Godbey 1999, pp. 337).[10] Housework is defined as time allocated primarily to food preparation and clean-up; house, yard, and car care; care of clothing and linens; care of family members; and marketing and management. Market work includes work for pay and commuting time. Time allocated to leisure or free time is time allocated primarily to social organizations, entertainment, recreation, and communications.[11] It, however, is defined residually for each individual as his/her allocate-able time endowment less hours of housework and hours of market work.

Time use data are derived as follows. For women and men age 16 to 64, who are not enrolled in school, the aggregate average allocate-able time endowment is assumed to be 14 and 15 hours per day, respectively.[12] In deriving aggregate average hours of paid work and of housework, a distinction is made between employed and not employed women and men (not in school) because over 1948 to 1996 these shares have changed significantly. (See Appendix figure 2).

My estimate for 1965 of the aggregate average housework for women and men age 16 to 64 (not enrolled in school) is 5.71 hours per day (7.34 hours for not employed and 3.72 hours for employed women) and 1.62 hours per day (2.17 hours for not employed and 1.58 hours for employed men), respectively. These estimates are based on information presented by Robinson and Godbey (1999), Bryant (1996), and Juster and Stafford (1991). In earlier years, recall that Bryant (1996) presents an estimate for *married* women for the mid-1920s of 7.35 hours per day.[13]

A significant amount of housework is associated with children, and I show in figure 1 that the average number of children, both less than age 5 and less than age 16, per 100 adults (age 16 to 64) did not follow a linear trend over 1920 to 1960 but completed a full cyclical swing. In 1920, there were 17.7 children under age 5 per 100 adults, but this number declined to a trough of 11.8 in 1938, which is a 40 percent decline. The number of children less than age 16 also declines—from 54.4 in 1920 to a trough of 39.6 in 1942, which is a 32 percent decline. Hence, over this time period, the demand for women's housework must have declined significantly.

Starting in the early 1940s the number of children per adult rose steadily until the early 1960s when it reached a peak of 19.4 for children under age 5 and 57.4 for children under age 16. Hence, over this period the demand for women's housework associated with caring for children must have increased. However, after 1962, the number of children under 5 per adult declined steadily reaching a trough of 11.5 in 1977 and then remaining approximately unchanged to1996. The number of children less than age 16 per adult showed a stronger cyclical downturn over 1962-1988 reaching a trough of 35.1. A notable finding is that in the mid-1920s, 1948, and mid-1960s the number of children under age 5 per 100 adults was approximately the same at 16

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(figure 1). Based on this information, I assume aggregate average housework in 1948 for women age 16 to 64 (who are not in school) was 7.21 hours per day (8.70 hours for not employed and 4.46 hours for employed women). This number is slightly lower than Bryant's estimate for married women in the mid-1920s.

For men, early information on aggregate average hours of housework is less readily available. However, when home heating was by noncentral heating equipment, men's housework included handling wood and coal and sometimes sawing wood to burn in fireplaces and stoves and disposing of ashes (Bryant 1986). As technical change in natural-gas and oil-fired central furnaces occurred and availability of low cost natural gas and heating oil increased, men's work associated with home heating declined and was eventually eliminated.

The Census data on home heating equipment extend back only to 1940 (U.S. Dept Commerce 1943). They show that in 1940 only 40.6 percent of U.S. housing units had central heating, and 76 percent of noncentral heating equipment used wood or coal. By 1950, central heating had increased to 49.5 percent of housing units, and the use of wood and coal in noncentral heating units had declined to 67 percent (U.S. Dept. Commerce 1953, 1954). With the rapid construction of new housing units that occurred in the 1950s, central heating increased to 66 percent of housing units in 1960 and then to 77 percent in 1970 (U.S. Dept. Commerce 1961, 1973).[14] In 1960, only 50 percent of noncentrally heated housing units used wood or coal.

Giving the changes in the technology of home heating over 1940 to 1970, the demand for men's housework associated with home heating must have declined over this period. Hence, in 1948 for men age 16 to 64 (not enrolled in school), I assume their aggregate average hours of housework was 1.87 hours per day (1.81 hours for employed and 2.52 hours for not employed men), which is 14 percent larger than in 1965.[15]

Based on estimates from Robinson and Godbey (1999) and Juster and Stafford (1991), I assume aggregate average housework of women's housework for women 16 to 64 years (not in school) in 1985 is 4.32 hours per day (5.56 hours for not employed and 3.65 hours for employed women). In 1996, I follow Robinson's and Godbey's evidence and assume average hours of women's housework are 3.72 hours per day (5.18 hours for not employed and 3.16 hours for employed women). For men 16 to 64 (not in school), I assume that aggregate average hours of housework in 1985 and 1996 is 2.18 hours (2.09 hours for employed and 2.89 hours for not employed men).[16] All the information on average hours of housework of women and men age 16 to 64 are summarized in figure 2 (see Appendix figure 3 for women and men 65 and older).

Although U.S. Department of Labor data may not be perfect for deriving data on hours of work for pay, for example, paid vacation and sick leave may be included, they provide a large amount of detailed data. They included average weekly hours of work for pay for women and men by age group (16-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65 and older). These data are used to derive weighted average hours of work for pay for men and women who are employed and not enrolled in school. For employed women 16 to 64 years (not in school), aggregate average weekly hours of work for pay was 37.6 in 1948, 35.1 in 1965, 35.2 in 1985, and 35.7 in 1996. For employed men 16 to 64 (not in school), aggregate average weekly hours for pay was 45.2 in 1948, 43.3 in 1965, 42.0 in 1985, and 42.3 in 1996. Thus, for employed women, average weekly hours declined early on in the post-war period and then a little after 1965. For employed men, the trend was downward to 1985 and then a slight increase. See Appendix figure 1 for a summary of the trend in these data on average hours worked for pay.

Although Robinson and Godbey (1999) provide a slightly different interpretation of hours of work for pay over 1965 to 1995 than the U.S. Department of Labor, they provide the

most extensive data on commuting time.[17] For 1965 to 1995, I use Robinson's and Godbey's estimates of average amount of commuting time to work for employed women and men. For 1948-1964, I make minor adjustment in the data from 1965, and they are converted to an annual basis.

The price of women's and men's housework and leisure is the average opportunity cost or wage. For employed women and men, the Bureau of Labor Statistics data on average hourly wage rates by age group (16-19, 20-24, 25-34, 45-54, 55-64, and 65 and older) are used to construct a weighted-average market-wage rate. For not-employed men and women, I apply the procedures of Smith and Ward (1985) to obtain an opportunity wage by age group, adjusted for selection into the not-employed group. Then, the average opportunity wage rate is constructed as a weighted average opportunity wage rate over all age groups for not-employed men and women. See figure 4 for the information on hourly opportunity wage of employed and not employed women and men. Final, an average wage rate for men and women was constructed as the weighted-average of the average wage rate for employed and not-employed men and women, respectively.

Consumers purchase nondurable consumption goods and services for consumption and acquire consumers' durables in order to obtain a flow of services to consumption. The treatment of consumers' durables here is the one employed by Jorgenson and Stiroh (1999), and it is the same as for the private business sector (Jorgenson 2001). Capital services are proportional to the stocks of assets, including computers, but aggregation requires weighting the stocks by rental prices rather than acquisition prices for assets. The rental price for each asset incorporates the rate of return, the depreciation rate, and the rate of decline in the acquisition price. The BEA

provides data on purchases of 12 types of consumer durable goods used in the services household durable good construction.

In the latest National Income and Product Accounts, the BEA uses superlative index numbers to construct quantity and price indexes for consumer goods. I also use a superlative index, the Tornqvist index, in all of my construction of price and quantity indexes for input categories. This is what permits substitution with major input categories to occur as relative prices of subcomponents change. The overall price index for the nine-input group making full-expenditures is, however, the Stone-price index (Stone 1954).

I employ the following translating variables: share of U.S. resident civilian population who are (i) less than age 5, (ii) 65 years of age or older, and (iii) non-metropolitan residents. Also, to hold technical change in the household sector constant, I construct a household technology index, which is proxied by the stock of U.S. patents of consumer goods (Griliches 1990; Huffman and Evenson 1993). This index is constructed as the summation of patents of consumer goods obtained from the U.S. Patents and Trademarks Office using trapezoidal shaped timing weights that sum to one over a 26 year time period. If the introduction of new goods is immediate and quality change for existing goods fully reflected in the National Income and Product data, then the stock of patents will not have a significant effect on expenditures shares. Otherwise, we expect significant impacts.

Trends in Key Variables

The behavior of expenditure shares for the nine major input groups over 1948-1996 is displayed in figure 5. The expenditure share for women's housework is 16 percent in 1948, and it displays a long-term negative trend with a slight reversal during the 1980s. The net decline over a half-century is about 7 percentage points. The share for men's housework is 8 percent in

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1948, and it declines slowly to 1960 as major technical advances were made in home heating equipment, and then shows almost no change over 1960 to 1975. It, however, rose over 1975 to 1985 and then declined slightly. The net decline over the half-century is about 1 percentage point. The expenditure share for food-at-home was 8 percent in 1948 and then declined steadily over the half-century, ending at 3.5 percent. The expenditure share for housework-purchased-substitute services was about 1.7 percent in 1948, declined very slowly to the mid-70s and then rose slightly, ending essentially where it started.

Turning to input services, the expenditure share for housing was 3.5 percent in 1948; it rose slowly and steady to 1970, remained essentially unchanged over 1970 to 1980, and then rose slowly and steadily to 1996. The net change is about 2.3 percentage points. The share for household appliance input rose initially with the massive investment in new housing during the late 1940s and 1950s then displays a slow decline to the mid-70s, thereafter rising very slowly. However, the net change over the half-century was negligible. The share spent on transportation input was 3.4 percent in 1948; it rose steadily to 1965 and then essentially remained unchanged to 1975. From 1975 to 1996 it rose slowly, ending at 5 percent. The share spent on recreation input was 2 percent in 1948, and it had a slight negative trend to the mid-70s and then reversed course with a slow increase to 1996. It was 1.3-percentage points higher at the end of the half-century than at the beginning.

In summary, the expenditure shares showing major movement over the last half-century are women's housework, men's housework, food-at-home, and transportation inputs. Since this is the first intensive examination of the structural change in the aggregate U.S. household sector in the post-War II period, I have nothing to directly compare these expenditure shares. When housework and leisure are excluded from the expenditure system, very different expenditure

shares result. For example, using personal income as the budget constraint, Costa (2001) gives the share of income spent on food at home as 15 percent in 1950 and 7 percent in 1994, and her expenditure share for recreation rose from 6 to 8 percent over the same period. These shares are much larger than I report. Deaton and Muellbauer (1980a), Jorgenson and Slesnick (1990), and Moschini (1998) also present expenditures shares using aggregate data.

The relative input prices (deflated by the Stone price index (Stone 1954) constructed from the 9 price indexes for major input groups, 1948 to 1996, are displayed in figure 6. Some distinguishing features of these relative prices are as follows. The relative price of women's housework rose about 30 percent from 1948 to 1980 and, thereafter, remained roughly unchanged. For men's housework, the relative price rose about 27 percent over 1948 to 1972 and then declined but stayed roughly 20 percent higher over the remainder of the period. The relative price of food-at-home has a strong negative trend, except for the world food-crisis years of the early 1970s, declining by about 60 percent over the last half-century. The relative price of housework-purchased-substitute services have an irregular trend, declining significantly over 1948 to 1960, rising over 1960 to 1980, and then declining. However, the net decline in the last half-century is about 20 percent. The relative price of housing declined steadily about 45 percent from 1948 to 1975 and then reversed its trend to increase slowly to 1996. The relative price of the household appliance input declined dramatically over 1948 to 1975, moved irregularly but trending upward over 1975 to 1985, and then declined. The net decline over the half-century was a dramatic 80 percent. The relative prices of transportation input moved in an irregular pattern over time and had a net decline over the whole period of 20 percent. The relative price of recreation input rose 1948 to 1958, declined steadily 1958 to the mid-80s, and then rose slightly. The net decline over a half-century was, however, 20 percent. The relative price of "other inputs"

rose very slowly over the half-century. Thus, over 1948 to 1996, my time series data on major household input categories show large relative price variation which can be an aid in estimating the parameters of the complete household demand system.

See table 1 for the variable list for the demand system and sample means of the variables.

The Empirical Results and Their Interpretation

In this study, nine expenditure shares are endogenous variables, so eight input demand equations are estimated. In the differenced form, the unknown parameters in the household demand system are: eight constant terms, which are commodity-specific coefficients for trend, 24 coefficients of the translating variables, 8 coefficients of the disembodied technical change variable, 36 price coefficients, and 8 budget coefficients. Hence, a total of 84 unknown parameters are to be estimated. I fit the transformed AIDS to 49 observations, 1948-1996, subject to symmetry, homogeneity and adding up conditions.

Results for the Demand System

Estimated coefficients of the AIDS-expenditure-share equations are reported in table 2 and of the estimated demand elasticities, evaluated at the sample means of the variables, are reported in table 3. The impact of per-capita total expenditures, demographic characteristics, and own-price effects are estimated relatively precisely. The impacts of cross-price effects are estimated less precisely, but this is to be expected because they represent price effects that are of secondary importance and about which much we know much less. The coefficients of the patent stock variable are non-zero and suggest that significant disembodied quality change is associated with the input groups.

The Hicksian own-price elasticity for each of the nine input groups is negative, being –0.49 for both women's and men's housework, -0.55 for food-at-home, -0.63 for recreation input,

-0.76 for housing input, -0.88 for both housework-purchased-substitute services and appliance input, and -1.09 for transportation. Also, the own-price elasticity of demand for "other inputs," i.e., men's and women's leisure and other goods and services, is –0.34.

Women's and men's housework are complements, but *all other input categories are substitutes for women's housework*. Food–at-home and recreation inputs are complements to men's housework, and the other 5 major input groups are substitutes. Housing and transportation inputs are also complements to food-at-home, and the other 5 input groups are substitutes. Transportation input and "other inputs" are complements to housework-purchased-substitute services, and the other 5 input groups are substitutes. For housing, five commodity groups are complements, all except for women's and men's housework and "other inputs." For the appliance input, all input groups are substitutes, except for housing which is a complement. For transportation, recreation is also a complement, but the other 4 input groups are substitutes. For recreation, the other 5 input groups are substitutes. For "other inputs," housing and appliances are complements, and the other 6 input groups are substitutes.

Hence, the cross-price elasticities among the nine input groups imply numerous margins where other inputs can be substituted for women's housework as the relative price of women's time changes. As seems reasonable, fewer input groups substitute for "other inputs," which are dominated by men's and women's leisure time. One plausible explanation for women's and men's housework being complements rather than substitutes is innovation in new time-saving technology tended to reduced the demand for both women's and men's housework.

Turning to the expenditure elasticities, men's housework, transportation, recreation, and women's and men's leisure (and other goods) are luxury goods, having per-capita expenditure elasticities larger than one. Women's housework, food-at-home, housing, and appliance inputs

are normal goods and have positive income elasticities that are less than one. Only housework-purchased-substitute services are inferior, having a negative expenditure elasticity. On the whole this set of expenditure elasticities has great appeal. In particular, with women's and men's leisure (and other goods) being a luxury, rising real per-capita expenditures over time imply a relatively large rightward shift in the demand for these inputs at a given price. With total allocate-able time fixed, this is a force for raising the shadow price of human time, or making human time seem more "scarce" (Linder 1970, Robinson and Godbey 1999).

The impact of the stock of consumer patents, introduced to hold constant quality change in purchased inputs, on the demand for major input groups ($*_j/s_j$) is not zero. The impact on all input groups is positive, except for housing and transportation. The impact measured as an elasticity at the sample mean of the expenditure share is largest (0.29 to 0.45) for men's housework, food-at-home, appliance input, and women's housework. For two of these four groups, the introduction of new goods has been relatively rapid, e.g., Hausman's (1996) seminal paper was on the introduction of breakfast cereals, an important food-at-home item. Also, innovations in consumer goods may have been targeted toward substitutes for women's housework which has shown the most rapid rise in relative price over the past half-century. For transportation, the elasticity with respect to patents is -0.45, and over the long term, hedonic pricing techniques were first applied to automobiles as a method for adjusting for quality change (Boskin *et al.* 1998; Griliches 1971).

The result suggests that an increase in the consumer-goods patent stock reduces the demand for women's housework relative to housing, transportation, and "other inputs" and increases the demand for women's housework relative to food-at-home and men's housework.

No significance change in the demand for women's housework relative to housework-purchased-substitute services, appliance input, and recreation occurs due to patenting activity.

The evidence is that the decreasing share of the U.S. population living in non-metropolitan areas during the post war era has had a significant effect on the demand for household inputs. Other things equal, it has increased the demand for women's housework, food-at-home, purchased housework-substitute services, and housing and decreased the demand for the other four input categories. Hence, the new data and methodology support a complete household-demand system having plausible price, income, and translating variable effects.

Cost-of-Living Comparisons

There exists a set of individual preferences such that exact aggregation exists from individuals to aggregate demand in the AIDS model (Deaton and Muellbauer 1980b). Hence, the AIDS-expenditure function for a given level of utility can be given an individual or an aggregate interpretation. I have held technical change at the household sector level constant with the patent index, and if no economies or diseconomies of scale occur in the household sector over time, an assumption that Jorgenson and Stiorh (2000) make, then the estimated coefficients of the AIDS model reported in table 2 and the actual and shadow prices of input groups can be used to construct the social-cost-of-living index (CLI), 1948-1996. The social CLI is displaced in figure 7, and for comparison the implicit price deflator for personal consumption expenditures (IPD) of the Bureau of Economics Analysis is also presented. *Over 1948-1996, my social CLI increases at an average compound rate of only 2.1 percent per year, but the IPD increases by a much higher rate of 3.5 percent per year.*[18]

Women's and men's housework (and leisure) are important inputs in household production. Also, services of durable goods rather than the investment in new durable goods are

the inputs producing commodities for consumption. Hence, failing to include housework and leisure and including durable goods rather than their services has biased the IPD upward significantly. Looking at figure 7, we see that the cumulative effect of this bias over nearly a half-century is large. Both indexes start at 1 in 1948, but in 1996, the social CLI is only 2.69 and the IPD is 5.25. The bias is large over the whole period, but especially so over 1980 to 1996. During this latter period of generally higher rates of CPI inflation, the IPD rose at an average of 8.8 percent per year, but the social CLI rose by only 4.1 percent. Hence, over the last 16 years the bias has been almost 5 percent per year.

For comparison, these differences are much larger than the Boskin *et al.* commission report of an upward bias of about 0.6 percent per year in the CPI due to inadequate adjustments for quality changes and Costa's estimate of CPI bias of less than 1 percent over our study period. The difference between Costa's and my estimates are especially large over the latter part of the period. Her estimate of a bias of 0.6 percent per year over 1982-1994 is much smaller than my estimate of 5 percent per year bias over 1980-1996. The reason for the difference is the much broader set of "goods" included in my social cost-of-living index, the fact that the relative price of human time changed very little over the the1980 to 1996 period but complex cross-price effects and quality improvements in consumption goods were operating to reduce the demand for women's housework. Also, the demand for women's leisure was growing. Hence, when relative prices are changing over time for a broad set of consumption goods and real income is rising, the size and composition of the consumption market basket is quite important to cost of living and real income/welfare estimates.

Conclusions and Implications

In this study, women's and men's housework and leisure and services of consumer durables have been introduced into a complete-household-demand system and permitted to adjust to relative price changes over a half-century. I showed that the price of women's and men's housework rose markedly relative to the price of other household inputs over 1948 to 1980 and then remained relatively unchanged to 1996. The expenditure share on women's housework was relatively large in 1948 (16 percent), and it has fallen dramatically during the first half of the period by 7 percentage points. For men's housework the share was much smaller in 1948, and it fell to the mid-1970s and then rose, ending approximately where it began. Furthermore, the new U.S. data grouped into nine major input categories supports a flexible complete household-demand system.

Although the parameters of the AIDS were estimated using data for the U.S., they were estimated with a methodology that minimizes their country-specific character and should make them applicable to other developed countries. The parameters of the estimated AIDS were used to evaluate price and expenditure elasticities, and these elasticities were quite plausible. All input groups are substitutes for women's housework, except for men's housework which is a complement. Hence, during 1948 to 1980 when the relative price of women's housework was rising in the U.S. dramatically, marketization of women's work occurred, i.e., a wide variety of inputs were substituted for women's housework, including housework-purchased-substitute services, and services of household appliances, housing, and transportation durable goods produced by the manufacturing and construction sectors and sold to the household sector. The increase in the consumer patent stock, a proxy for quality of consumer goods, also tended to reduce the relative intensity of women's housework compared to other inputs.

The AIDS-cost or expenditure-function associated with the AIDS complete-demand system in this study shows a remarkable picture of the social cost-of-living for the U.S. postwar World War II period. It holds constant socio-demographic attributes, quality as reflected in the stock of patents for consumer goods, and scale of the household sector. Over the post-war period, my social cost-of-living index grew at an average rate of *1.4 percent per year slower* than the BAE's implicit-price deflator for personal consumption expenditures and o*ver 1980-1996, it grew about 5 percent per year slower.* Hence, U.S. household's real welfare or income was rising over the post-World War II era much faster, 1.4 to 5 percent per year, than traditional computations lead one to believe.

Although I cannot claim that my time use data for women's and men's housework and leisure are accurate to the minute, they are plausible and cannot be far removed from true values. They most likely show the appropriate direction and order of magnitude for changes over the post-World War II era. Much additional research remains to be done on time allocation of Americans and on household demand systems. The new national time-use survey of the BLS will create a public good available for examining household demand systems and time use in the 21st century.

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Eisner (1989) has suggested extending the national income accounts to include the household sector, but he does not report demand function estimates.

In the IPD the BEA uses prices of services of owner-occupied housing, i.e., implicit rental rates, rather than the price of houses. One period when the IPD and CPI performed quite differently was over 1975-1982 due to very different treatment of housing. The BLS used the cost of new houses, new mortgage interest rates, property taxes and insurance, and maintenance costs (see Dougherty and Van Order 1982). This was a period where mortgage interest rates rose much faster than rental rates on housing.

This general point was emphasized by Becker 1965 and Linder 1970.

The 1981 data contain an appropriate number of rural households but the 1965 data were for urban households only (Juster and Stafford 1991), which suggests a slight underestimate for the aggregate average.

Robinson and Godbey's time use data are derived from time diary information.

Joint use of inputs or joint production for households is no more prevalent than for farms, and agricultural economists have successfully applied production theory there (e.g., see Griliches 1965; Huffman 1980; Huffman and Evenson 1989; Mundlak 2000).

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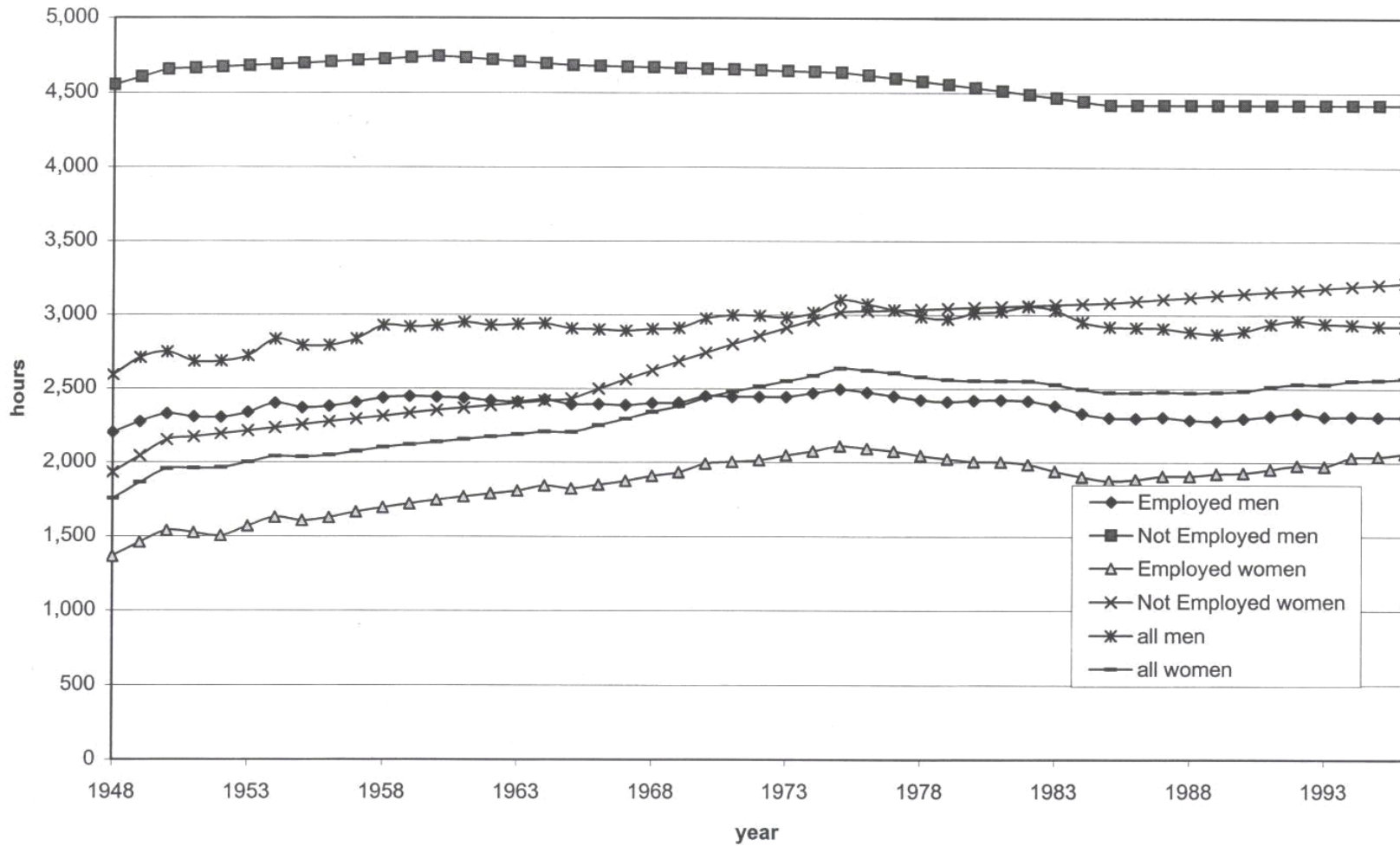
Figure 1. Number of Children per 100 Adults, 1920-1996
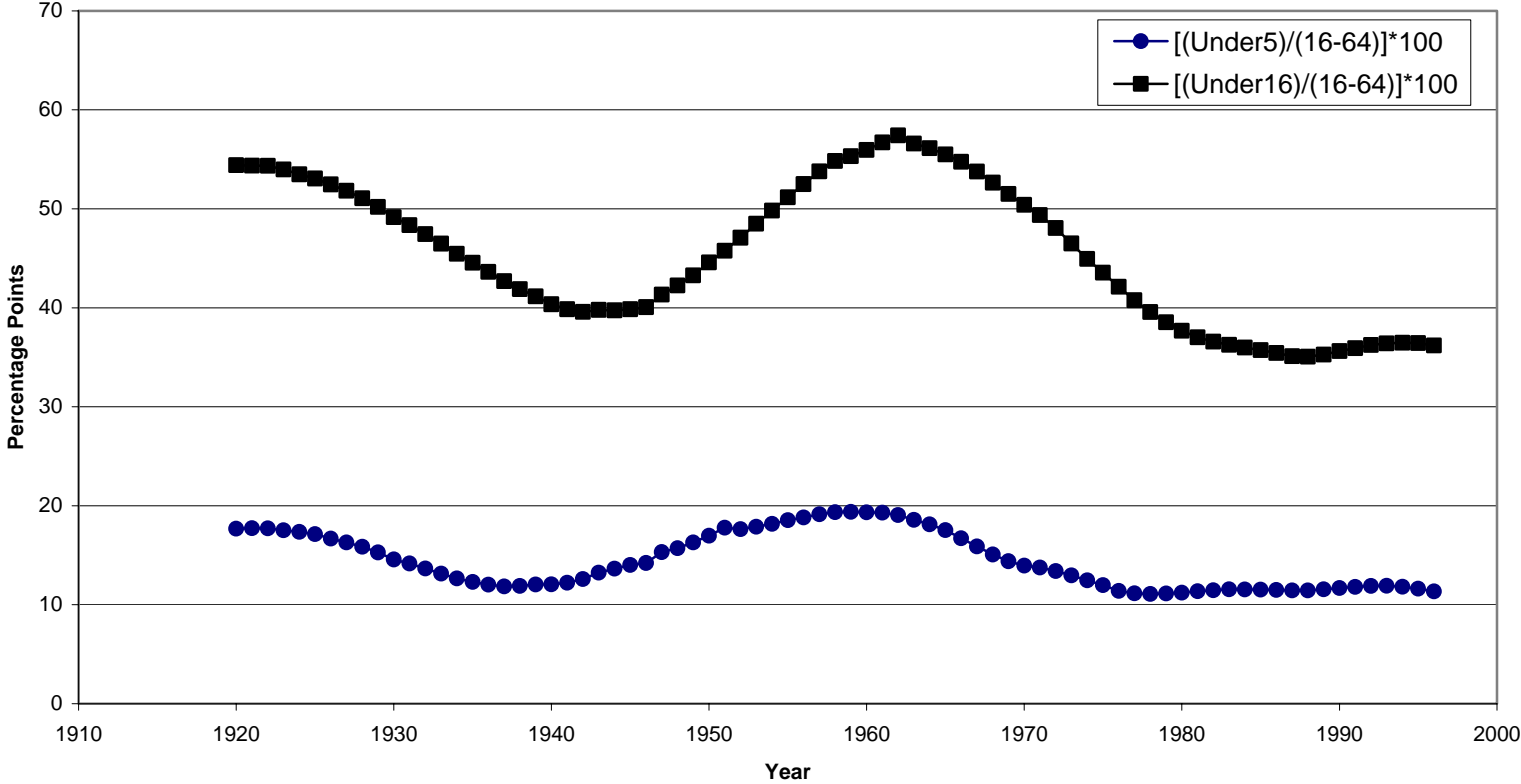
Figure 2. Average annual hours of household work of employed and not employed men and women, 16-64 years of age: 1948-1996
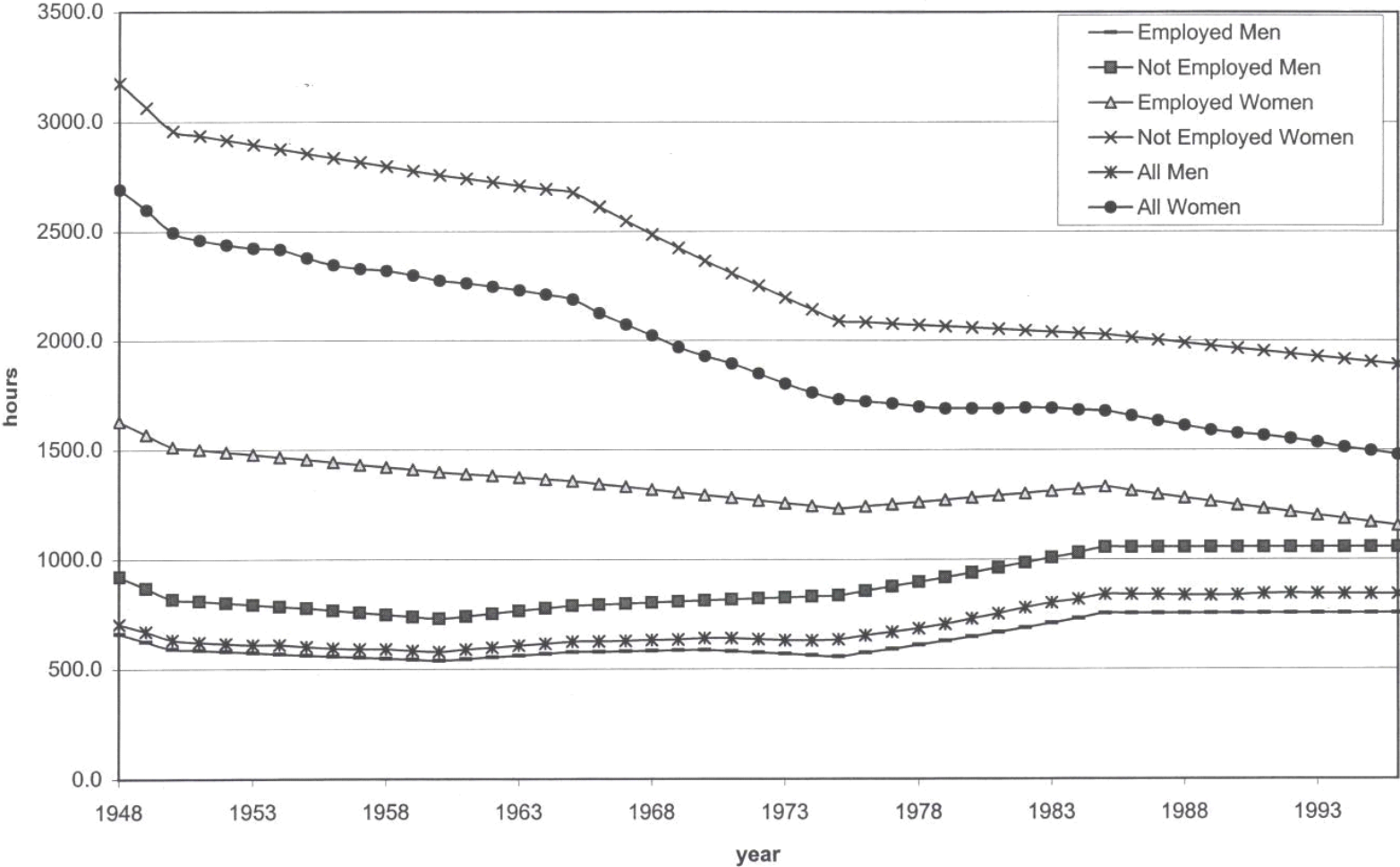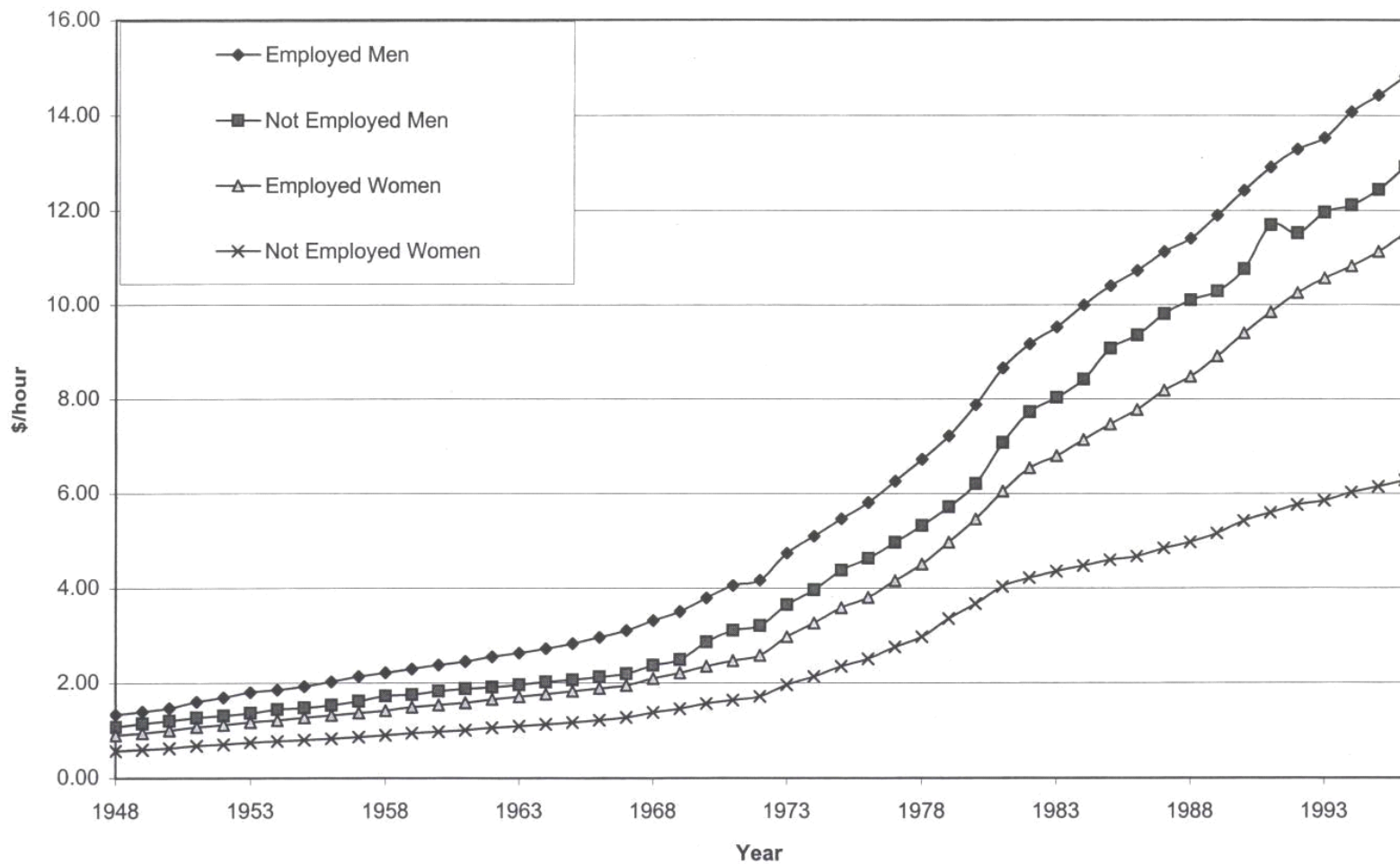
Figure 3. Average annual hours of leisure for employed and not employed men and women, ages 16-64 years: 1948-1996
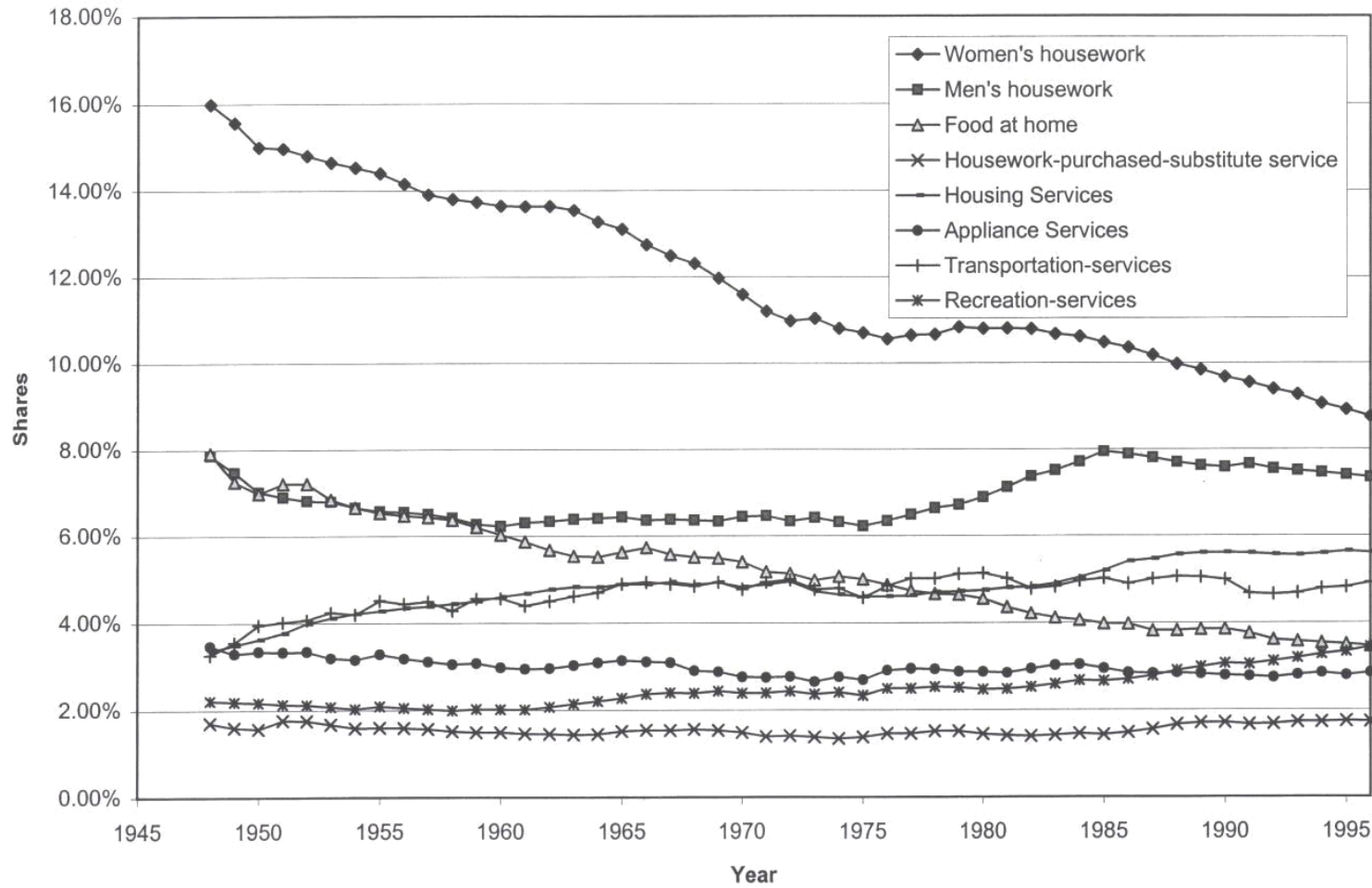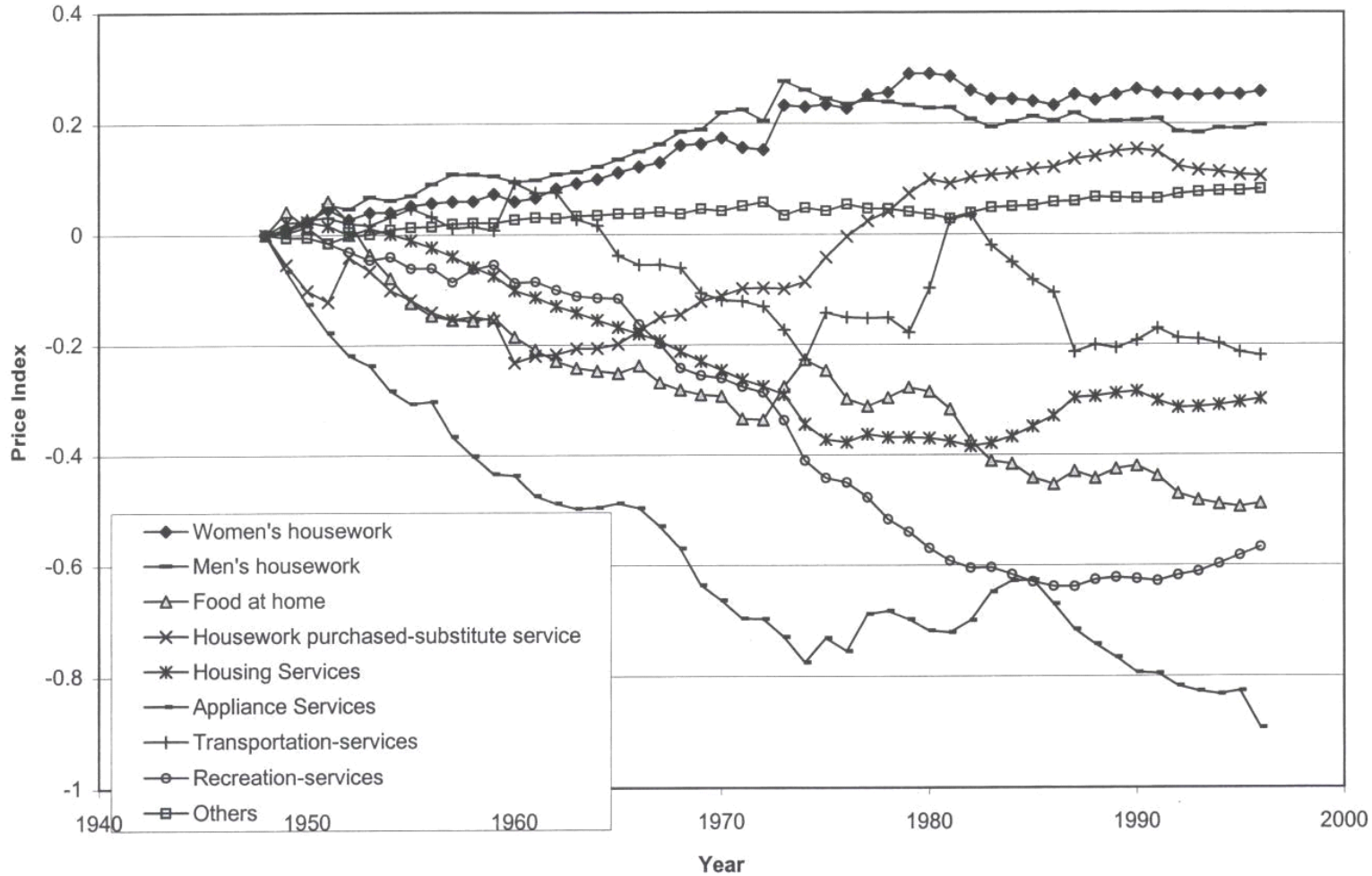
Figure 4. Hourly opportunity wage for employed and not employed men and women, 16-64 years of age: 1948-1996

Figure 5. U.S. Household expenditure shares, 1948-1996

Figure 6. Relative prices of inputs for U.S. household production, 1948-1996

Figure 7. The AIDS cost of living index and implicit price deflator for personal consumption expenditures, 1948-1996
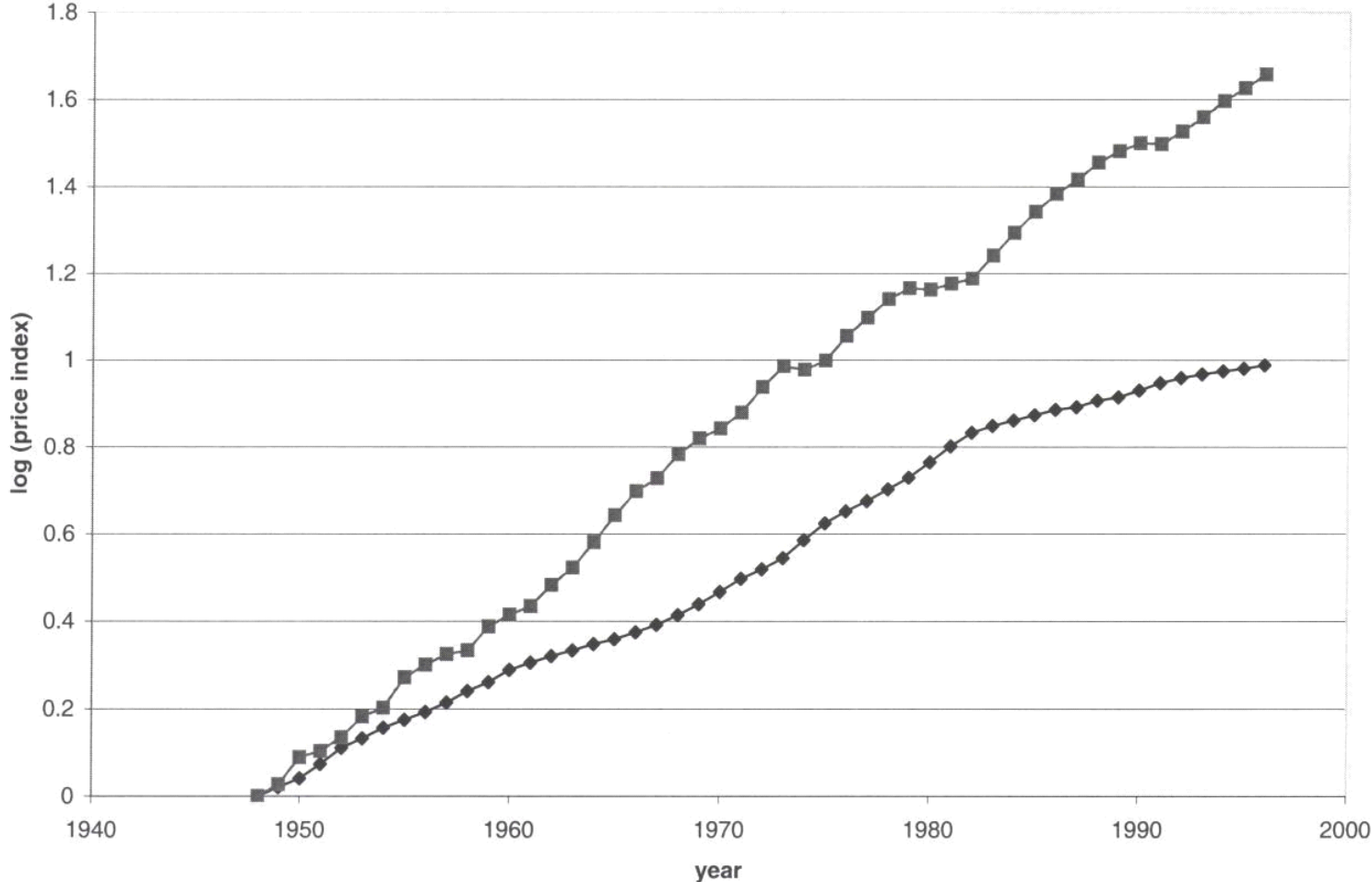
Table 1. Definitions of Variables and Sample Means

Variable	Definitions	Sample Mean
s_1	Expenditure share for women's housework	0.119
s_2	Expenditure share for men's housework	0.069
s_3	Expenditure share for food at home	0.052
s_4	Expenditure share for housework purchased substitute services	0.015
s_5	Expenditure share for housing input	0.048
s_6	Expenditure share for household appliance input	0.030
s_7	Expenditure share for transportation input	0.047
s_8	Expenditure share for recreation input	0.025
s_9	Expenditure share for "other inputs" (men's and women's leisure, medical services, and other consumer goods and services)	0.595
AGE < 5	Share of the resident population that is less than five years of age	0.090
AGE ≥ 65	Share of resident population that is over 65 years of age and older	0.104
non-metro	Share of resident population living in non-metropolitan areas	13.21
Consumer patents	The stock of patents of consumer goods, trapezoid weights over 26 years	3262.7
F/(N·P)	Average real annual household expenditure per person (price level 100 in 1987)	4369.5
P_1	The price of women's housework, or the opportunity wage	0.528
P_2	The price of men's housework, or the opportunity wage	0.541
P_3	The price index of food at home	0.598
P_4	The price index of purchased housework substitute services	0.512
P_5	The price index of housing input	0.565
P_6	The price index for household appliance input	0.580
P_7	The price index for transportation input	0.611
P_8	The price index for recreation input	0.660
P_9	The price index for "other inputs" (e.g., men's and women's leisure, medical services, and other outlays)	0.552

Table 2. ISUR Estimate of U.S. Household Demand System for Inputs: AIDS (Shares) 1948-1996 (Asymptotic Standard Errors in Parentheses) [1]

Variables	Women's housework (1)	Men's housework (2)	Food-at-home (3)	Purchased-substitute services (4)	Housing input (5)	Appliances input (6)	Transportation input (7)	Recreation input (8)
Constant	0.287 (0.305)	-0.300 (0.236)	0.066 (0.264)	0.254 (0.147)	0.348 (0.129)	0.180 (0.156)	0.131 (0.236)	-0.177 (0.120)
AGE $\leq$ 5	0.424 (0.157)	0.184 (0.125)	0.118 (0.144)	-0.008 (0.087)	0.062 (0.080)	0.073 (0.093)	-0.026 (0.146)	-0.053 (0.075)
AGE $\geq$ 65	-0.360 (0.282)	-0.161 (0.223)	-0.240 (0.261)	0.229 (0.146)	0.311 (0.131)	0.025 (0.155)	-0.024 (0.243)	0.021 (0.122)
Non-metro	-0.0006 (0.0004)	0.0001 (0.0003)	-0.0065 (0.0004)	-0.0007 (0.0002)	-0.0004 (0.0002)	0.0004 (0.0003)	0.0003 (0.0005)	0.0003 (0.0002)
Consumer patent stock	0.035 (0.014)	0.032 (0.011)	0.019 (0.013)	0.002 (0.007)	-0.002 (0.006)	0.009 (0.008)	-0.021 (0.014)	0.002 (0.01)
ln[F/(N·P)]	-0.034 (0.027)	0.009 (0.021)	-0.011 (0.023)	-0.022 (0.013)	-0.025 (0.012)	-0.018 (0.013)	0.007 (0.021)	0.014 (0.011)
LnP$_1$	0.046 (0.014)							
LnP$_2$	-0.028 (0.010)	0.030 (0.011)						
LnP$_3$	0.007 (0.007)	-0.012 (0.006)	0.021 (0.008)					
LnP$_4$	0.003 (0.006)	0.015 (0.005)	0.004 (0.004)	0.002 (0.005)				
ln P$_5$	0.003 (0.006)	0.008 (0.006)	-0.008 (0.004)	-0.004 (0.004)	0.009 (0.007)			
ln P$_6$	0.003 (0.005)	0.004 (0.004)	-0.001 (0.004)	0.004 (0.003)	-0.009 (0.003)	0.002 (0.004)		
ln P$_7$	0.005 (0.005)	(0.002) (0.004)	-0.003 (0.005)	-0.003 (0.003)	0.007 (0.003)	-0.001 (0.003)	-0.006 (0.006)	
ln P$_8$	-0.002 (0.005)	-0.008 (0.005)	-0.000 (0.003)	0.008 (0.003)	-0.007 (0.004)	-0.000 (0.003)	-0.003 (0.002)	0.009 (0.004)
R^2	0.996	0.969	0.989	0.707	0.990	0.832	0.874	0.981

System estimated after taking first-differences, which is consistent with ρ = 1 for a first-order autoregressive assumption for the disturbance in the original share equations.

Table 3.   Estimates of Price and Income Elasticities: AIDS Model with Nine Input Groups, U.S. Aggregate Data, 1950-96.

Commodity/Input groups (i)	Prices (j)									Income/ Expenditure Elasticity
	1	2	3	4	5	6	7	8	9	
	compensated (e_{ij}^{*})									
1) Women's housework	-0.493	-0.164	0.110	0.043	0.070	0.053	0.085	0.007	0.289	0.713
2) Men's housework	-0.283	-0.489	-0.116	0.229	0.166	0.087	0.077	-0.085	0.414	1.136
3) Food at home	0.253	-0.154	-0.553	0.098	-0.109	0.002	-0.015	0.016	0.462	0.793
4) Purchased housework substitute services	0.330	1.019	0.328	-0.882	-0.184	0.295	-0.139	0.075	-0.841	-0.420
5) Housing input	0.173	0.238	-0.119	-0.060	-0.757	-0.159	-0.093	-0.113	0.888	0.480
6) Household appliance input	0.211	0.202	0.004	0.153	-0.255	-0.887	0.008	0.024	0.541	0.392
7) Transportation input	0.217	0.112	-0.017	-0.046	-0.095	0.005	-1.087	-0.029	0.937	1.151
8) Recreation input	0.032	-0.236	0.034	0.047	-0.219	0.029	-0.055	-0.628	0.997	1.579
9) "Other input"	0.058	0.048	0.040	-0.022	-0.268	0.027	0.074	0.041	-0.338	1.133

Appendix figure 1. Annual hours worked for pay of men and women 16 years of age and older: 1948-1996
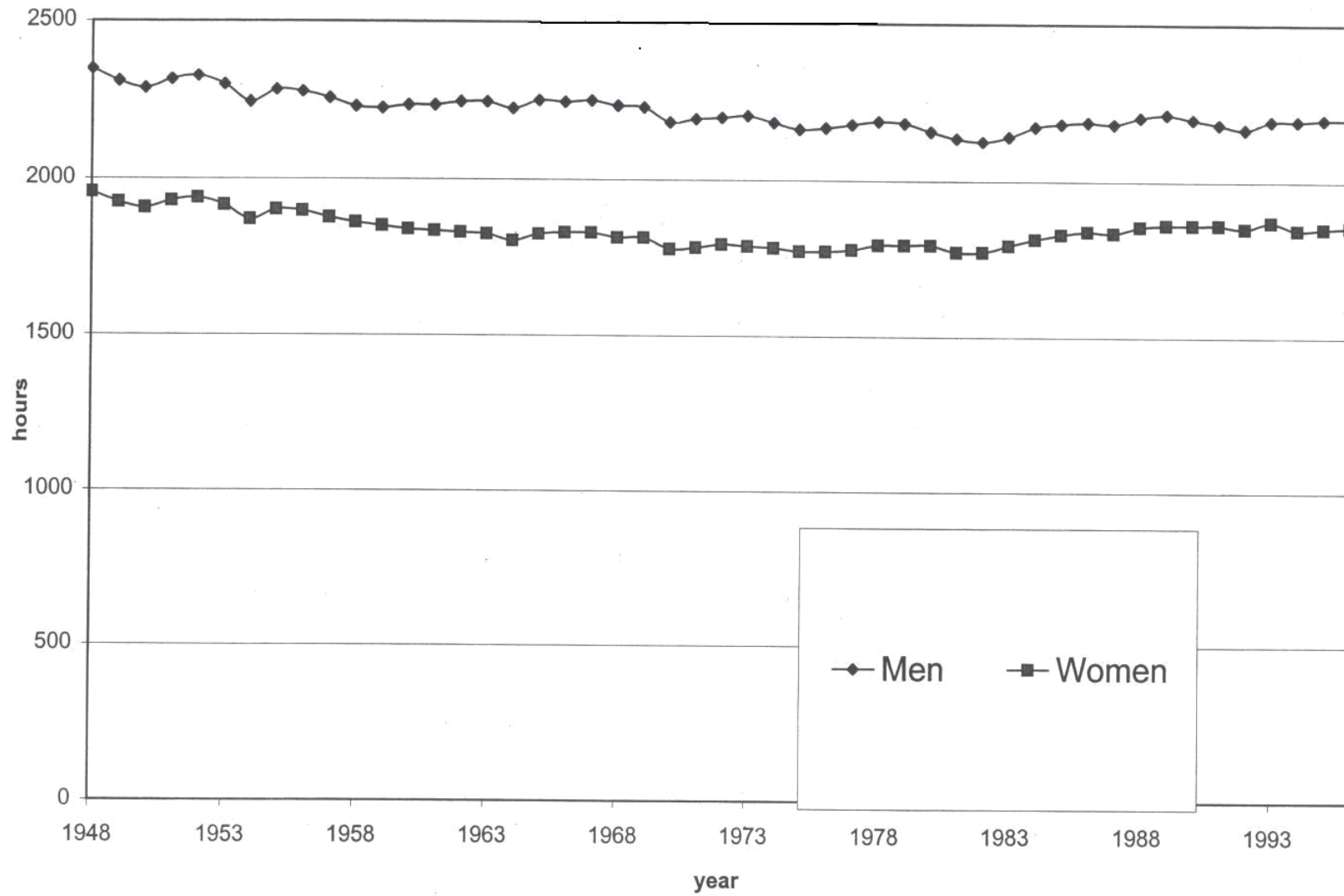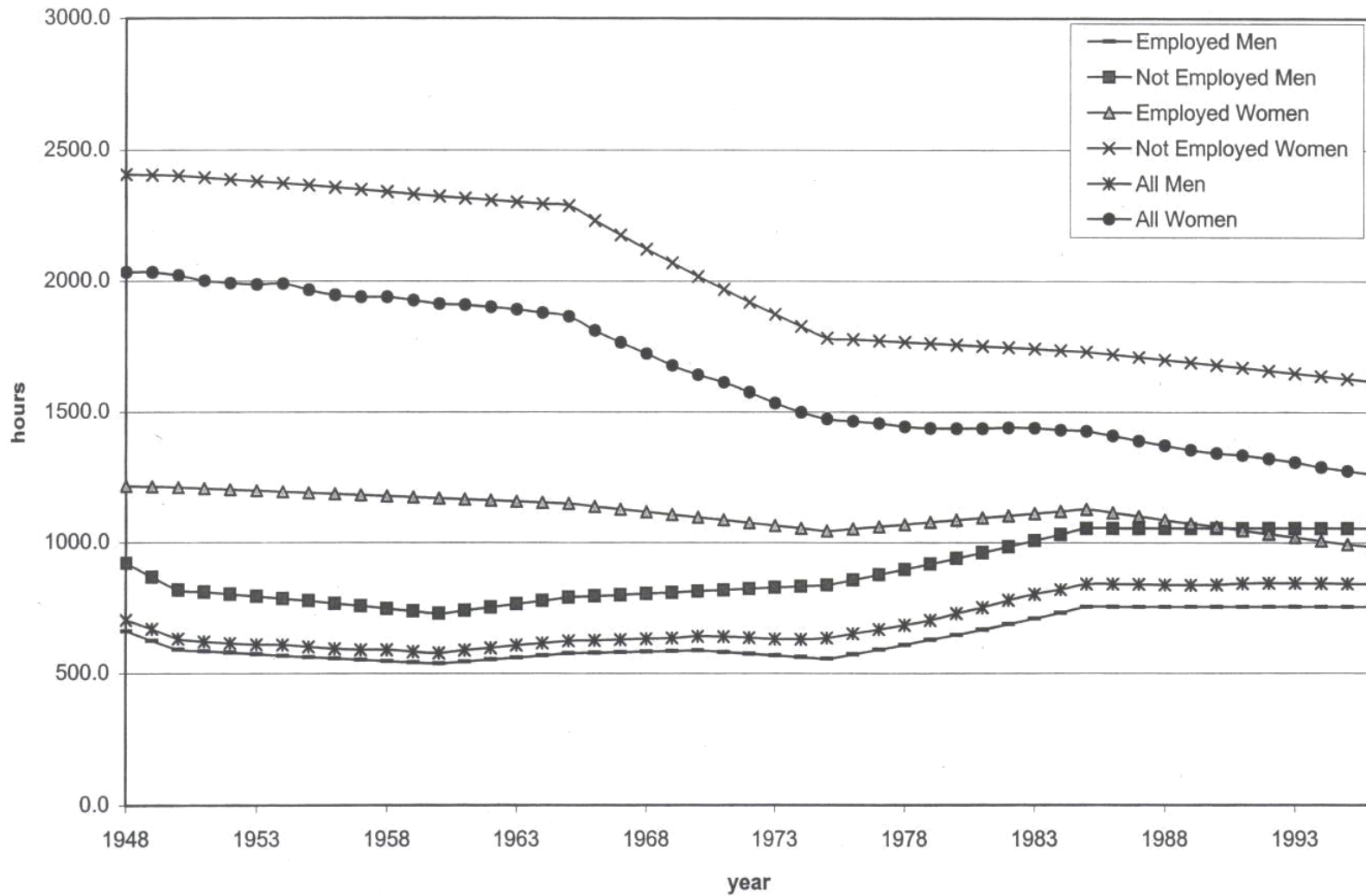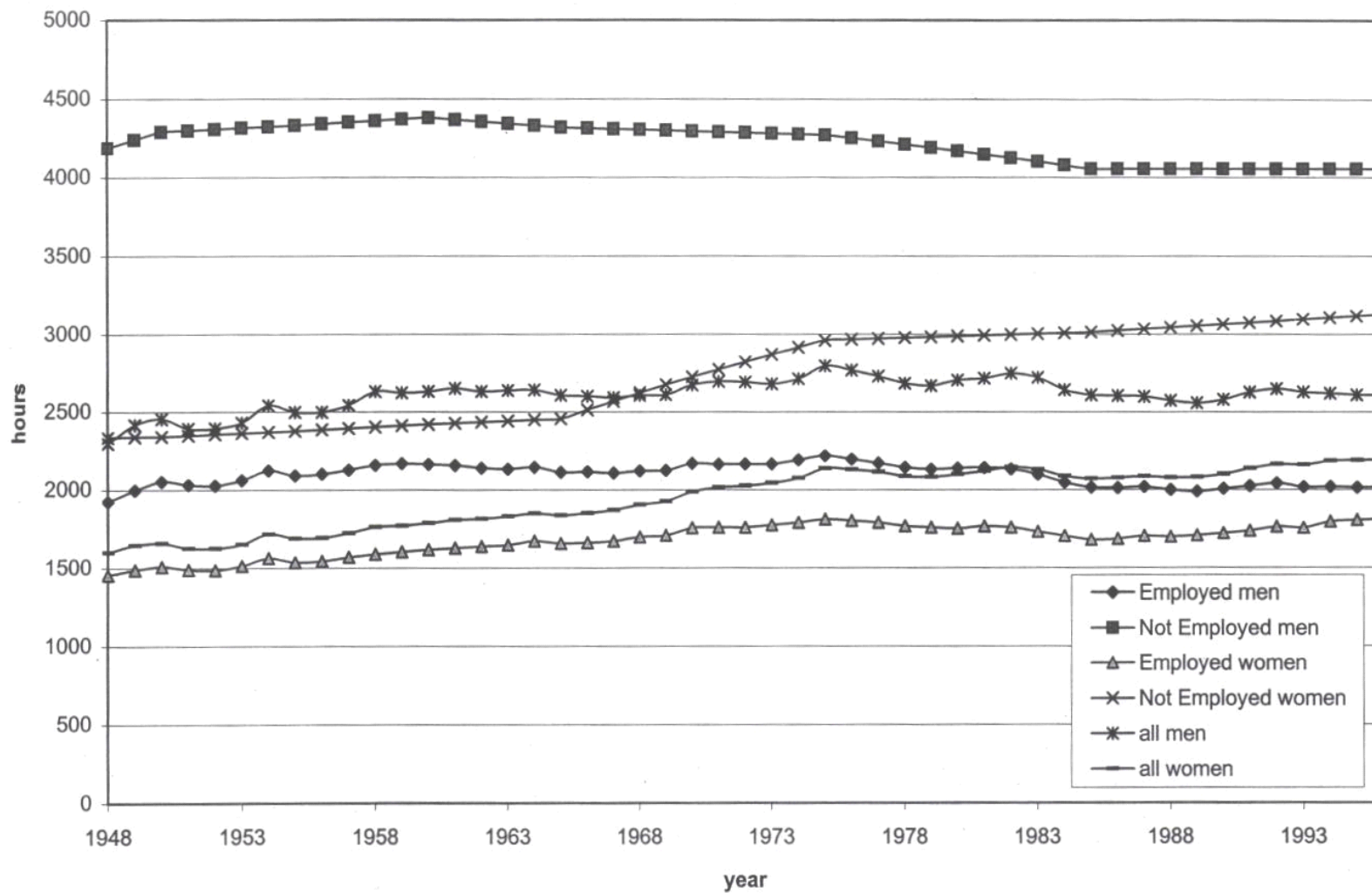
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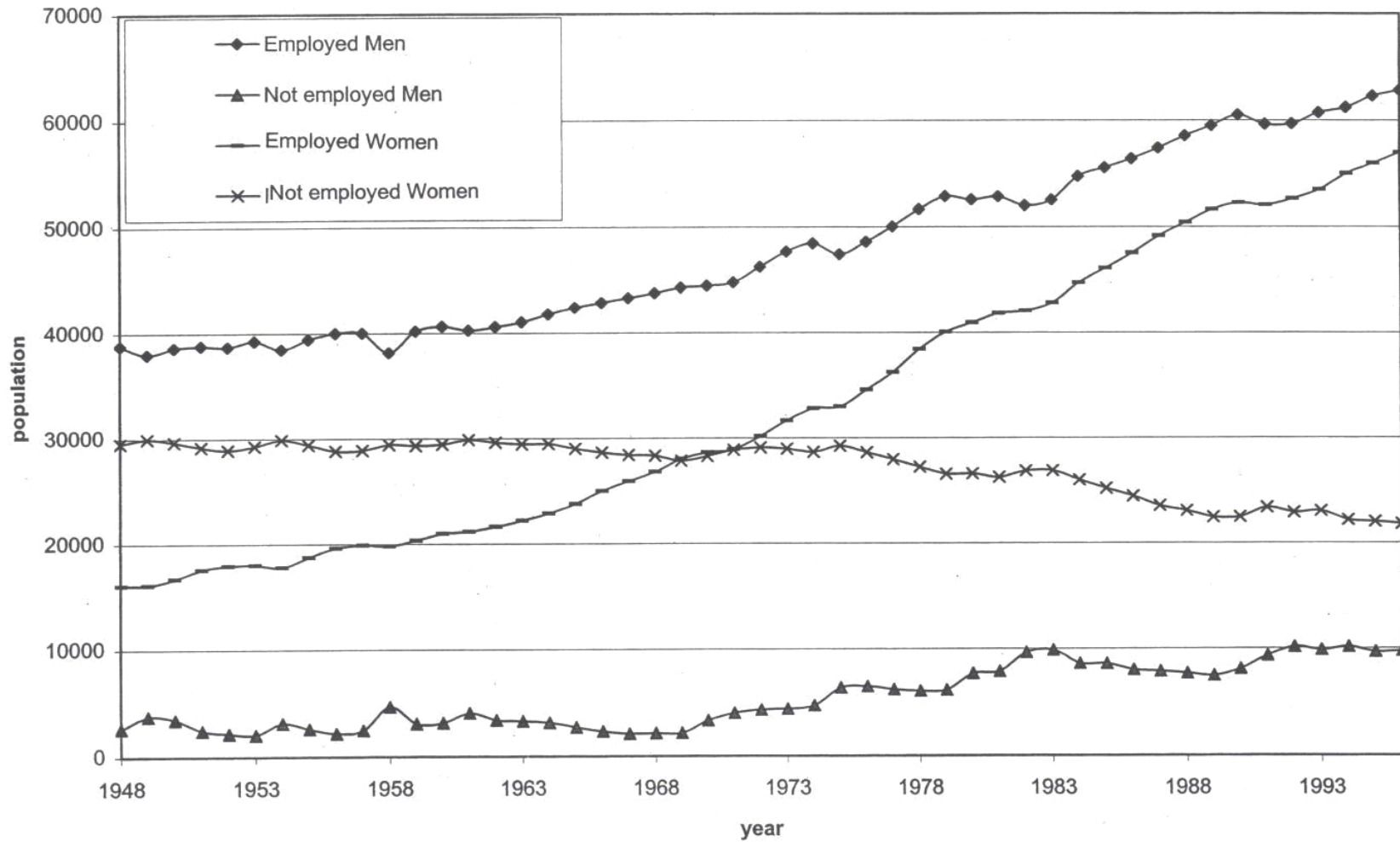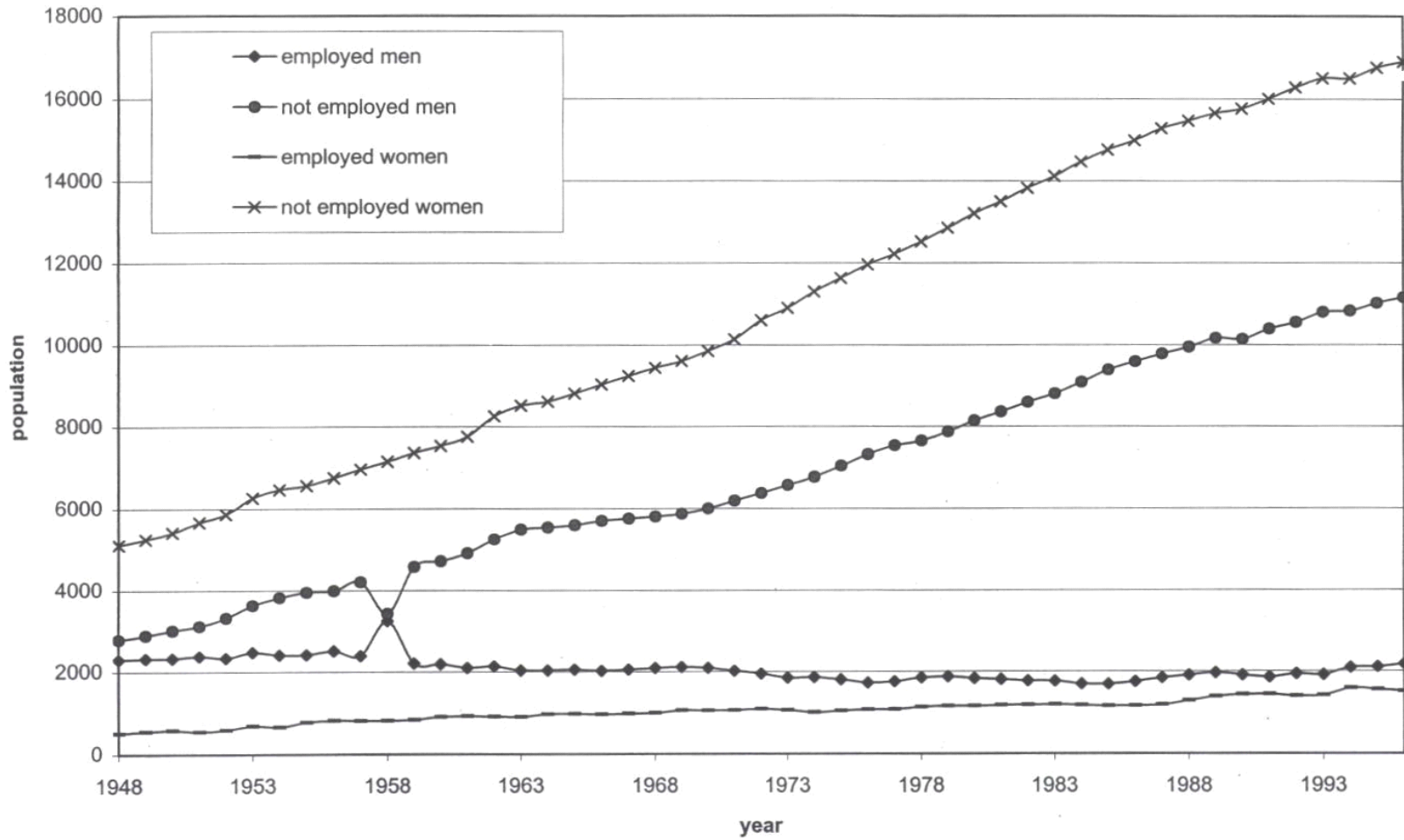
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ENDNOTES

[1] Eisner (1989) has suggested extending the national income accounts to include the household sector, but he does not report demand function estimates.

[2] In the IPD the BEA uses prices of services of owner-occupied housing, i.e., implicit rental rates, rather than the price of houses. One period when the IPD and CPI performed quite differently was over 1975-1982 due to very different treatment of housing. The BLS used the cost of new houses, new mortgage interest rates, property taxes and insurance, and maintenance costs (see Dougherty and Van Order 1982). This was a period where mortgage interest rates rose much faster than rental rates on housing.

[3] This general point was emphasized by Becker 1965 and Linder 1970.

[4] The 1981 data contain an appropriate number of rural households but the 1965 data were for urban households only (Juster and Stafford 1991), which suggests a slight underestimate for the aggregate average.

[5] Robinson and Godbey's time use data are derived from time diary information.

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