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The Story Behind the Post-War Decline in Women's Housework: Prices, Income, Family Size, and Technology Effects in a Demand System

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The Story Behind the Post-War Decline in Women's Housework: Prices, Income, Family Size, and Technology Effects in a Demand System

By Wallace E. Huffman*

Abstract

This paper applies production theory to define a new set of inputs for U.S. households over the post-World War II period and uses newly constructed data on some of these inputs to fit a complete household-demand system, including inputs of women's and men's housework, and seven other input groups. The econometric results yield plausible price and income elasticities. Women's and men's housework are shown to be complements, rather than substitutes, but the other seven input categories are substitutes for women's housework. Since the price of all inputs, except for men's housework, has fallen significantly relative to the price of women's time over the post-war period, substitution away from women's household work is a major factor in its decline over the study period. Much of this decline, however, occurred from 1948 to 1980. Although the number of children under age 5 per household grew from 1948 to 1960 by 25 percentage points, which tended to increase the demand for women's housework, family size declined from 1960 to 1985 by 27 percentage points and contributed to the post-60s decline in the demand for women's housework. Also, the increasing share of the population aged 65 and older reduced the demand for women's housework. These demographic changes are shown to have impacted women's housework by a much larger magnitude than men's housework. Women's housework is a normal good, so rising real per capita nonlabor income in the post-war period has offset some of the above forces for decline. The parameters of the demand system are also used to make some standard of living comparisons for the post-war period.

Key Words: Complete-demand system, household production, housework, women, price effects, income elasticities, post-World War II.

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The Story Behind the Post-War Decline in Women's Housework: Prices, Income, Family Size, and Technology Effects in a Demand System

A major revolution in the household sector occurred in the 20th Century as a result of inventions of labor-saving electrical appliances, central heating, piped hot and cold water, flush toilets, manufactured clothing, processed foods, the falling relative prices of these goods, and adoption by households of new basic facilities, electrical appliances, and other new goods (see figure 1). At the beginning of the 20th Century, housework was hard physical work and consumed a large amount of woman's time, but by the eve of the century it had been converted into modest amounts of relatively light work. A careful examination of these changes has been limited by a scarcity of needed data.[1]

World War II brought hardships to the household sector—resources, especially the production of durable goods, were diverted to produce tanks, planes, jeeps and guns to win the war. The stock of household appliances declined significantly over 1940 to 1945 (Greenwood et al., 2005). During the immediate post-World War II period, the production of durable goods was redirected to civilian uses, including household appliances, automobiles, and houses. The technology embodied in these goods also changed steadily. By the 1980s, computers were introduced into electrical appliances, which decreased greatly their need for direct personal attention as they carried out various tasks in the home. Jorgenson and Stiroh (1999) have shown that the U.S. household sector responded in the past 25 years in a predictable way to the dramatic decline in the relative price of computers and other information technologies.[2]

The objective of this paper is to apply production theory in order to define a new set of inputs for U.S. households over the post-World War II period and use newly constructed data to fit a complete household-demand system, including inputs of women's and men's housework and seven

other aggregate input categories. The main hypotheses are that the relative price of women's time has risen dramatically relative to other household inputs over the study period, that market inputs have been substituted for women's housework, but that women's housework is a normal good and rising nonlabor income has off-set some of the price effects. This is a new approach to understanding the dramatic change in U.S. women's housework over the post-War II period that emphasizes price and income effects within a household demand structure.[3] With new econometric parameter estimates, we are able to explain much of the change in the demand for women's housework in the post-war era. Moreover, the harried feeling of U.S. adults during the late 20th Century is most likely due to the high real price of time by historic standards and not to less leisure.

A generalized version of Becker's productive household model, i.e., that inputs are used to produce abstract commodities that are the source of utility to households, provides the basic framework. However, given that the commodities/outputs are unobservable, I follow Jorgenson and Stiroh, systematically applying production theory to the inputs going into household production and focusing 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 inputs are housework and leisure of a household's adult members. Capital services are proportional to the stock of consumer durables, 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, households demand housework, leisure, 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).

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 from 1948 to 1980 and minimal thereafter. Results from econometric estimates of the household demand system show *women's and men's housework are complements rather than substitutes*, *but other major input categories are substitutes for women's housework*. Major forces behind the reduction in women housework were the rise in real price of women's time, change, largely decline, in the real price of other inputs, decline in the share of the population under age 5, and rise in the share aged 65 and older. Women's housework is shown to be a normal good and, hence, rising real income was a force pulling in the opposite direction.

The paper begins with a discussion and assessment of time uses by U.S. women and men over the post-World War II period. Section two and three present the economic model of consumer demand and the econometric model, the data, and the variables. 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. women who are not in school has changed significantly over the post-World War II period. The changes for men have been modest. Legal and social restrictions on married women's work in the labor 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 for a century. Although this restriction was temporarily loosened during World War II, it was not until about 1950 that long-term job opportunities for married women started to open up, including those for regular part-time work. 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 over 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 the hours 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 labor 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 time 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, 18-64 years of age and for age 65 and older. Focusing on women 18-64 years 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 2). For men, the rate of change is positive but slow. In conclusion, these prior studies suggest that the hours of women's household work have declined, especially over 1965 to 1975, and the 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 laundry and ironing, carrying water, doing spring house cleaning, and speed up the preparation of meals and many other things (Bryant 1986; Greenwood et al., 2005).

Major changes in households include less time allocated by women to preparing meals and meal clean up at home and more meals consumed away from home. Frequently, 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 thermostatically controlled burners and ovens speed cooking and give control over the temperature with low supervision, which leads 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 (see figure 1) has been substituted for this work. "To make" versus "to buy" was an important decision in 1948, but today, ready-to-wear clothing is the norm, which is a major labor saver for women, and hand-made is the exception. In the late forties, U.S. households used relatively primitive motorized clothes-washing machines with wringers. Doing the laundry involved handling heavy wet clothing, including carrying it outside in baskets to be hung on elevated clotheslines to dry in the open air, with perhaps in sun. Today, almost all households have an automatic clothes washer and dryer (figure 1) or access to a Laundromat, and wash-and-wear or non-wrinkle (and hence, non-iron) fabrics are available, and "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 relative to the more distant past (Bryant 1986). Mechanical and electrical power (see figure 1) have been substituted for women's time and effort. Also, automatic clothes washers and dryers, having enhanced performance attributes associated with a 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, also, have been adopted by households, and they are both a time and human energy saver, and facilitate sanitizing at the same time, which is a quality improvement.

Leisure time, or time allocated primarily to leisure activities, 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, but leisure activities remain relatively human-time intensive. 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, video games, and surfing the web (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 or DVDs, 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. In the 1950s and 1960s 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 are changing regularly (Hausman 1996; Boskin *et al.* 1998). Excluding prices of goods when "new," and then much later introducing them into a cost-of-living index leads generally to overestimates of the true cost-of-living and underestimates in social welfare. *The point we will make is that excluding the price of human time from cost of living indexes in the past is analogous to excluding the price of "new" goods from the cost of living index, i.e., one can expect excluding new goods or housework and leisure from the cost of living index to cause a major bias in true cost of living.* Designate as the virtual (or implicit) price p_1^V for a "new" good X_1 or goods that are initially excluded from the cost of living index, we can consider the consumer's optimal and voluntarily chosen level of X_1, which might be zero:

$$X_1 = x_1^c(U_0, p_1^V, p_2).^7 \qquad (1)$$

That is, the virtual price is an implicit function of the zero quantity of a new good (housework, leisure and services of consumer durables), 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}) equal the Hicksian-demand functions without free availability (x_2^c):

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

Virtual Prices and Consumer Demand

The virtual-price demand system presented below is developed using a modification of the cost function associated with the almost-ideal-demand system (AIDS) and draws on previous work by Deaton and Muellbauer (1980b) and Huffman and Johnson (2004).[8] The virtual-price form of the cost function of the AIDS in logarithmic form is:

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

where $C(U_0, p_1^V, p_2)$ is the cost function, p_2 is an *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 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 upon 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 an equation for the expenditure share denoted as $w_i|_{p_1^V}$:

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

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.,

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

Qualitative demographic or "translating" variables, which are related to equivalence scales (Muellbauer 1977; Deaton and Muellbauer 1980a), are introduced into the demand systems to incorporate effects associated with the age distribution of the population and its metro-nonmetro compositon:

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

where $\alpha_i^{**} = \alpha_{i0} + \sum_{s=1}^{S} \delta_{is} D_s$, D_s are the translating variables, and the following restrictions are imposed on the demand system: homogeneity $\sum_{j=1}^{k} \gamma_{iVj} + \sum_{j=k+1}^{n} \gamma_{ij} = 0 \; for \; \forall i$; symmetry $\gamma_{iVj} = \gamma_{jVi}$ and $\gamma_{ij} = \gamma_{ji}$; and adding up $\sum_{i=1}^{n} \alpha_i^{**} = 1, \sum_{i=1}^{n} \delta_{is} = 0, \; \sum_{i=1}^{k} \gamma_{iVj} + \sum_{i=k+1}^{n} \gamma_{ij} = 0 \; for \; \forall j$, and $\sum_{i=1}^{n} \beta_i = 0$.

Cost-of-Living Indexes

Modern treatments of social income or national income accounting date back to Hicks (1939, p. 172). He states, "The purpose of income calculations in practice is to give people an indication of the amount which they can consume without impoverishing themselves." In this framework, consumption and investment are largely limited to legal goods and services that pass through the marketplace. This means that they miss output associated with household production, leisure, rising life expectancy, changes in the quality of resources and the environment. It is production-based

because it attempts to measure the rate of production at a given time (Nordhaus 2003, p. 9-13; Becker et al. 2005).

The most commonly used measure of the cost-of-living in the United States is the U.S. Department of Labor's consumer price index (CPI) (Boskin *et al*. 1998; Diewert 1976). This is essentially a Laspeyres price index—$L(p^1, p^0) = \sum p_1x_0/\sum p_0x_0 = \sum p_1x_0/I_0$, 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 treatment of housework, leisure and durable household goods on welfare. The implicit price deflator for personal consumption expenditures (IIPD) of the Bureau of Economic Analysis (BEA) is somewhat better than the CPI for long-term comparisons because it is a superlative price index (Diewert 1976), 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.

Following Deaton and Muellbauer (1980a), the true-cost-of living index, including "new goods" can also be obtained by invoking 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

$$P(p^0, p^1, U^0) = C(U^0, p^1)/ C(U^0, p^0), \qquad (9)$$

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, indirect utility can be calculated. The compensating variation given by the difference in cost functions or CV = $C(p^1, U^0)$–$C(p^0, U^0)$ can be evaluated directly. Positive differences indicate that the households 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 full-income household AIDS demand system to be fitted to U.S. aggregate data is derived from equation (8), including symmetry, homogeneity, and adding-up restrictions, and presented here

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

where α_{i0} is a time-invariant unobserved effect for input *i*, p_{1jt}^V is the price of nontraditional inputs, e.g., housework, leisure, and of services of household durable goods, p_{2jt} is the price of traditional inputs, e.g., food at home, housing, $\phi_i t$ represents the effects of time trend-dominated factors on input

i, u_{it} is a random disturbance term that captures other effects on the demand for input i and year t, $i = 1, ..., n$ denotes the input categories, and $t = 1, ..., T$ denotes the years (Wooldridge 2002, p. 251-258).[9] Trend (t) controls for the effect of changes in air quality, life expectancy, marriage and divorce rates, and hence, improves the quality of the estimates of the γs and β, which are central to price and income elasticity estimates. 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.[10]

Equation (10) has two random unobserved terms–α_{i0} and u_{it}. Furthermore, α_{i0} may be correlated with the other regressors and u_{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 equation (10) satisfy the usual stochastic assumptions (having a zero mean, finite variance, first-order autoregressive process over time, and contemporaneous correlation across share equations). To remove unobserved 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 effect α_{i0} 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).[11]

The (n-1) differenced 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, which is of secondary interest to this study, will be deleted in this application, and its parameters recovered using the restrictions on the parameters. The estimation is conducted using the ISUR procedure in SAS.

The Data

Econometrically, I am limited on the total number of major input categories across full-expenditures or parameters of the demand system that can be estimated from an annual time series, but aggregation or formation of groups is somewhat arbitrary. I am interested in the extent to which men's housework, services of household appliances, housing, purchased consumer goods and services substitute for women's housework. I minimize aggregation problems by using superlative index numbers (Diewert 1976) to aggregate components within major input groups.

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 goods), 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 the objectives of this study and limits on the total number of parameters that can be estimated for an aggregate demand system, I define nine major and comprehensive 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 furnishings 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).[12]

Clearly since our main objective is to explain the decline in women's housework over time, it makes no sense to aggregate men's and women's housework together.[13] In this study, the so-called "new goods" are women's and men's housework and leisure which have traditional been excluded from household demand system, and the imputed services of consumer durables that replace purchases of consumer durable goods. However, I use current- and constant-dollar consumer expenditure components on nondurable goods and services taken directly from the National Income and Production Accounts (U.S. Dept. of Commerce).

I choose to scale down the average daily time endowment from 24 hours to 14 or 15 hours per day by excluding time allocated to sleep, personal care, and eating (i.e. personal care). No evidence exists of significant trend in time allocated of personal care by women and men, i.e., personal care time is unresponsive to prices and income or even trend (see Robinson and Godbey 1999, pp. 337).[14] Ramey (2005) also uses the same modified time endowment in her research. Each individual of aged 16 and older who is not in school is assumed to allocate his/her modified time endowment among housework, market work, including commuting, and leisure. 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; which is considerably broader than what is frequently labeled as "core housework"—cooking, cleaning and washing dishes, doing the laundry, and cleaning and straightening the house. Market work includes work for pay and commuting time to work. Time allocated to leisure or free time is time allocated primarily to social organizations,

entertainment, recreation, and communications.[15] It, however, is defined residually for each individual as his/her allocatable time endowment less hours of housework and hours of market work.

The modified time endowment is set as follows. For women and men aged 16 to 64 who are not enrolled in school, the modified endowment is assumed to be 14 and 15 hours per day, respectively. The size of these modified time endowments is based on information presented in Robinson and Godbey 1999, pp. 337, and the average size of these gender differences is also supported by the information presented by Juster and Stafford (1991) for U.S. men and women in 1965 and 1985. For women and men who are 65 years of age and older, the modified time endowment is assumed to be 13 and 14 years, respectively. [16] 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 from 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 aged 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) presented an estimate for *married* women for the mid-1920s of 7.35 hours per day.[17]

A significant amount of housework is associated with children and child care, and I show in figure 2 that the average number of children, both less than age 5 and less than aged 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 is a 40 percent decline. The number of children less than age 16 also

declined—from 54.4 in 1920 to a trough of 39.6 in 1942, 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 age 5 per adult declined steadily, reaching a trough of 11.5 in 1977 and then remaining approximately unchanged until 1996. The number of children younger than age 16 per adult showed a stronger cyclical downturn from 1962 to 1988, reaching a trough of 35.1. A notable finding is that in the mid-1920s, 1948, and the mid-1960s the number of children under age 5 per 100 adults was approximately the same as at age 16 (figure 2). 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 (see figure 1), men's housework included handling wood and coal and sometimes chopping and 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 in most homes.

The Census data on home heating equipment extend back only to 1940 (U.S. Dept. of 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).[18] In 1960, only 50 percent of noncentrally heated housing units used wood or coal.

Giving the changes in the technology of home heating from 1940 to 1970, the demand for men's housework associated with home heating must have declined over this period. Hence, in 1948 for men aged 16 to 64 (not enrolled in school), I assume their aggregate average hours of housework were 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.[19]

Based on estimates from Robinson and Godbey (1999) and Juster and Stafford (1991), I assume aggregate average hours of women's housework for women 16 to 64 years (not in school) in 1985 are 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 aged 16 to 64 (not in school), I assume that aggregate average hours of housework in 1985 and 1996 are 2.18 hours (2.09 hours for employed and 2.89 hours for not employed men).[20] All the information on average hours of housework of women and men age 16 to 64 is summarized in figure 3 (see Appendix figure 3 for women and men 65 and older).[21,22,23] Ramey's (Ramey 2005, figure 10) measures of average weekly hours of housework for women and men aged 18-64 follow very similar trends as my estimates for all women and men in figure 3.

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 include 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 aged 16 to 64 (not in school), aggregate average weekly hours of work for pay were 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 were 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 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.[24] See Appendix figure 1 for a graphical summary of data on average hours worked for pay.

Although Robinson and Godbey (1999) provide a slightly different interpretation of hours of work for pay from 1965 to 1995 than the U.S. Department of Labor, they provide the most extensive data on commuting time.[25] 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.

Figure 4 summarizes my estimates of hours of women's and men's leisure. They show that women on average have less leisure time than men, but for men and women, the average amount of leisure time rose to 1975, and then decreased a little bit.

The price of women's and men's housework and leisure is taken to be 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 5 for the information on hourly nominal opportunity wage of employed and not employed women and men. Finally, an average nominal wage rate for men and women was constructed as the weighted-average of the average nominal wage rate for employed and not-employed men and women, respectively.

Consumers purchase nondurable goods and services for consumption and acquire consumers' durables in order to obtain a flow of services to consume. 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 Bureau of Economic Analysis (BEA) provides data on purchases of 12 types of consumer durable goods used in the construction of service measure for household durable goods.

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 (Diewert 1976; Deaton and Muellbauer 1980a, p. 174-175), in all of my construction of price and quantity indexes for input categories. This is index permits substitution within 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 over the nine input groups (Stone 1954).

I employ the following demographic translating variables: the share of the U.S. resident civilian population who are (i) less than age 5, (ii) 65 years of age or older, and (iii) who have a non-

metropolitan residence.[26] Data on the services of household durables were constructed by Dale Jorgenson, and they include quality adjustments. However, disembodied technical change might also occur over time in the U.S. household sector, even after adding housework, leisure time, and services of durable goods to the input set. To account for this, I construct a household technology index as the stock of U.S. patents of consumer goods (Griliches 1990; Huffman and Evenson 2006). This index is the summation of patents of consumer goods obtained from the U.S. Patents and Trademarks Office and aggregated over time using trapezoidal-shaped timing weights that sum to one over a 26-year time period.[27] If the introduction of "new goods" is immediate and the 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 expenditure shares. The null hypothesis is of no effect.

Trends in Key Variables

Full-income based consumption or expenditures per capita in 1987 dollars were $3,667.6 in 1948 and $10,085.4 in 1996 with a mean value of $7,858.8. Hence, the average annual rate of growth of full income based consumption per capita over the sample period was 2.06 percent. The level and trend in eight of the nine expenditure shares, 1948-1996, using the full income concept are displayed in figure 6. The full-income 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 1948, and it declines slowly to 1960, as major technical advances are made in home heating equipment, and then shows almost no change from 1960 to 1975. It, however, rose from 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 slowly until the mid-70s and then rose slightly, ending essentially where it started. Although some may have the conception that the expenditure share on this item has risen dramatically over the sample period, it has not changed. A major factor is the steady technical advance in fabrics used in making clothing, making them easier to care for, and wages of domestic servants and restaurant workers that have remained low due to immigration of low skilled workers since 1980 relative to all U.S. workers.

Turning to input services, the full-income expenditure share for housing was 3.5 percent in 1948; it rose slowly and steady to 1970, remained essentially unchanged from 1970 to 1980, and then rose slowly and steadily to 1996. The net change is an increase of 2.3 percentage points. Although the share of full income spent on food at home is larger in 1948 than for housing, this is reversed by 1980 and in 1996, the share spent on housing is about twice as large as for food at home.[28] The share for household appliance input rose initially with the massive investment in new housing during the late 1940s and 1950s, and 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, rising steadily to 1965, and then essentially remaining 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, had a slight negative trend to the mid-70s. It then reversed course with a slow increase to 1996, ending the Century 1.3-percentage points higher than at the beginning.

In summary, some of the nine expenditure shares show major changes over the last half-century—women's housework, men's housework, food-at-home, and transportation inputs. Since this is the first extensive examination of structural change in the aggregate U.S. household sector over the post-War period, I am limited in the type of comparisons that I can make. 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 expenditure shares using aggregate data with traditional measures of household consumption.

The 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 7. When homogeneity of the demand function in nominal prices and income is imposed, these real or relative prices become the key ingredients to creating the price changes used in the econometric analysis. 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 has an irregular trend, declining significantly from 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 cumulating into a 45 percent decline from 1948 to 1975 and then reversed its trend to increase slowly until 1996. The relative price of the household appliance input declined dramatically from 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 from 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 a large relative price variation that can be an aid in estimating the parameters of the complete household demand system.

The Empirical Results and Their Interpretation

In this study, nine expenditure shares are endogenous variables, and they are explained by nine real or relative prices, by real income or total expenditure, share of the population under age 5 and over age 65, share living in non-metropolitan areas, and the consumer patent stock. However, because expenditure shares add up to one and within and cross-equation restrictions are imposed in equations (8) and (10), we only need to estimate eight input demand equations with the associated restriction suggested by the theory. In the differenced form, the unknown parameters in the household demand system are: eight constant terms that 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 income 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 full-income AIDS-household demand system are reported in table 2, and the estimated demand elasticities, evaluated at the sample means of the variables, are reported in table 3. The impact of per-capita total expenditures/income, 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 we know much less. The coefficients of the patent stock variable are non-zero; some are significantly different from zero, and hence we reject the hypothesis of no effect of disembodied quality change in the full-income household demand system. The demand system explains at least 97 percent of the variance in the household's expenditure share for women's and men's housework, food-at-home, housing input, and "other inputs." It explains more than 83 percent of the variance in the share spent on household appliance and transportation inputs. Seventy percent of the variance in the share spent on purchased substitutes for housework are explained by the demand system. Overall, this is an outstanding performance of the demand system.

The Hicksian own-price elasticity for each of the nine input groups is negative, at -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 -0.09 for transportation. Also, the own-price elasticity of demand for "other inputs," i.e., largely men's and women's leisure, is –0.34.

It is an empirical issue as to whether women's and men's housework are substitutes or complements. Our empirical results, however, show that women's and men's housework are complements, but *all other input categories are substitutes for women's housework.* An explanation for women's and men's housework being complements is that women and men perform different types of housework and that these tasks complement rather than substitute for one another. For example, men sometimes play with or help entertain the children and care for the lawn, but they infrequently perform significant amounts of other types of indoors household chores and child care (Robinson and Godbey 1999; Aguiar and Hurst 2006, table 2 and 3). Purchases housework substitutes and appliance services are as anticipated substitutes for both women's and men's housework. Food–at-home and recreation inputs, however, are complements to men's housework,

and the other four major input groups are substitutes. Housing and transportation inputs are also complements to food-at-home, and the other five input groups are substitutes. Transportation input and "other inputs" are complements to housework-purchased-substitute services, and the other five 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. Clearly we anticipate that appliance services and housing truly complement one another—they are used together. For transportation, recreation is also a complement—they used together, but the other four input groups are substitutes. For recreation, the other five input groups are substitutes. For "other inputs," which is largely leisure time, housing and appliances are complements. Hence, these latter inputs make leisure more enjoyable, and the other six input groups are substitutes of the "other inputs" category.

Hence, the cross-price elasticities among the nine input groups imply numerous margins where other inputs have been substituted for women's housework as the real or relative price of women's time rose in the post-War II period. As seems reasonable, fewer input groups substitute for "other inputs," which is dominated by men's and women's leisure time.

Turning to the expenditure/income elasticities, men's housework, transportation, recreation, and "other inputs" (largely women's and men's leisure) are luxury goods, having expenditure/income elasticities greater 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. This negative income elasticity may be surprising, but readers can easily confuse price and income effects her. Increased use of this input category is largely due the rising price of time and not due to rising real nonlabor income. On the whole, this set of expenditure elasticities has great appeal. In particular,

with the "other inputs category," which is largely women's and men's leisure being luxury goods, rising real per-capita income over time imply a relatively large rightward shift in the demand for these inputs at a given price. With total allocatable 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 disembodied technical change in the household sector is not zero. The precise impact is on the demand for each major input group isδ_j / s_j. The impact on all input groups, including household appliances, 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 inoput groups, the actual 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 technical change in the household sector 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 significant change in the demand for women's housework relative to housework-purchased-substitute services, appliance input, and recreation occurs due to patenting activity.

The impacts of a change in the share of the population that is aged 5 years or less is 2.3 times larger for women's housework than for men's housework, and the impact of an change in the share of

the population 65 years of age and older is 2.2 times larger on women's housework than on men's housework. Hence, women's housework is more responsive to the changing age composition of the U.S. population than is men's housework.

In conclusions, the new data and methodology support a complete household-demand system having plausible price, income, and translating variable effects.

Relative Contributions to the Change in Women's Housework

From 1948 to 1996, women's average annual housework declined from 2,594 hours to 1,398 hours, which is a 61.8 percent. How much of this change can be explained by my full-income based demand equation for women's housework and the actual changes in explanatory variables over this 49 year period? I use the derived elasticity estimates of the demand for women's housework with respect to each of the regressors, evaluated at the sample mean (see table 4).[29] These calculations show that 12.2 percentage points (or 20 percent) of the reduction in women's housework is due to the rise in women's wage relative to the Stone price index (also see figure 7). Another 17.6 percentage points of the reduction (or 28 percent) is due to the change in the prices of the other 8 inputs. The decline in children under age 5, increase in adults over age 65, and decline in share of households in nonmetro areas decreased the demand for women's housework by 25.1 percentage points (or 41 percent). Thus, these three sets of factors account for 54.9 percent of reduction in women's housework (or roughly 89 percent of the total reduction). However, technical change in the household sector increased the demand for women's housework a little (less than 1 percent) over the 49 year period, but the rise in real per capita income increased it by 72.1 percent. Since the AIDS is nonlinear, this complicates the accounting process where there are large, rather than small marginal, changes in relative prices and real income. I conclude that the demand equation for women's

housework in the AIDS provides important new information about the relative importance of economic factors to the long-term decline in women's housework in the post-War II period.

Cost-of-Living Comparisons

A set of preferences for individuals exists such that exact aggregation occurs in the aggregate AIDS model (Deaton and Muellbauer 1980b). Hence, the AIDS-expenditure function for a given level of utility can be given either an individual household or an aggregate sector interpretation. In the econometric analysis, I have held technical change (patent index) and trend constant, and if no economies or diseconomies of scale occur in the household sector over time, as assumed by Jorgenson and Stiorh (2000), the estimated coefficients of the full-income AIDS model reported in table 2 and the actual and shadow prices of inputs can be used to construct the new cost-of-living index (CLI), 1948-1996.[30] My new full-income based CLI is displaced in figure 8, and, for comparison, the implicit price deflator for personal consumption expenditures (IPD) of the Bureau of Economic Analysis is also presented. *Over 1948-1996, my 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.*[31]

Women's and men's housework (and leisure) are important inputs in household production. Also, services of durable goods rather than 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 8, we see that the cumulative effect of this bias over a half-century is large. Both indexes start at one in 1948, but in 1996, my CLI is only 2.69 and the IPD is 5.25. The bias is large over the whole period, but especially so from 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 official 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 is especially large over the latter part of the period. Her estimate of a bias of 0.6 percent per year from 1982-1994 is much smaller than my estimate of a 5 percent per year bias from 1980-1996. The reasons for the difference is the much broader set of "goods" included in my social cost-of-living index, and the fact that the relative price of human time changed very little over the 1980 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. Moreover, the upward adjustments in the standard of living due to my computations from systematic employment of a productive household model, but ignoring improvements in life expectancy, are significantly larger than those suggested by Nordhaus (2003, pp. 27) due to rising life expectancy from 1950-1995. 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 full-income, complete-household-demand system and permitted to adjust to changes in relative prices and real income over a half-century. I have shown that the price of women's and men's housework rose markedly relative to the price of other household inputs from

1948 to 1980, and then remained relatively unchanged to 1996. The expenditure share for women's housework was relatively large in 1948 (16 percent), and fell 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 until the mid-1970s and then rose, ending approximately where it began. My demand system explains a remarkable 99 percent of variation in U.S. households' expenditure on women's housework over the post-World War II period. Equally remarkable, it also explains 97 percent of the variation in the share spent on men's housework. 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 make them broadly applicable. The parameters of the estimated AIDS were used to evaluate price and expenditure elasticities, and these elasticities were quite plausible. All input groups are shown to be substitutes for women's housework, except for men's housework, which is a complement. Hence, during the period from 1948 to 1980 when the relative price of women's housework was rising dramatically market inputs were substituted for women's (and men's) housework, and the U.S., marketization of women's work occurred—women's work moved from the household to the labor market by roughly equal amounts. U.S. households adopted new facilities and electrical appliances that were manufactured using industrial technology and marketed by private firms to household. The services of these inputs substituted for women's housework. This released some of women's time for work in the labor market. 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 cost-of-living for the U.S. in the post-World War II

period. It holds constant key demographic attributes, technical change in the household sector, and scale of the household sector. Over the post-war period, my full-income based 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 *from 1980 to 1996, it grew about 5 percent per year slower.* Hence, U.S. households' standard of living or real welfare was rising over the post-World War II era much faster by 1.4 to 5 percent per year, than traditional cost of living computations led one to believe.

To be able to apply demand theory to explain the post-World War II reduction in demand for women's housework, I first needed to construct annual estimates of hours of housework, leisure, and other major inputs based upon the best available data and plausible assumptions. I then was able to fit the almost ideal demand system to these data and to obtain new estimates of the price and income elasticities of demand, change in population demographics, and technical change in the household sector. This methodology is in contrast to the approach taken by Greenwood et al. (2005), who developed a calibration model for the aggregate U.S. economy, and then used it to simulate impacts of aggregate price, income and technical change on household production over the 20th Century. Arguably, my approach is superior because it gives much greater latitude for the data to inform the size of key parameters—at least for the post-World War II period—where better data are available. For example, I find the rise in the real price of women's time over the study period caused substitution toward other inputs, including appliance services, purchased substitute services, housing, and transportation. In contrast, Greenwood et al. rely heavily upon labor-saving technical change to explain the reduction in the demand for women's housework. Hence, our results support Jorgenson (2001) results for the general economy, that is, relative price changes have been large for many input

groups over time and these price changes account for much of the resource adjustments that has occurred over time.

Although some of my data may contain deficiencies, they are plausible and present quite an accurate picture of the magnitude of change in the structure of U.S. households over 1948 to 1996. 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, but these latter data are of no particular value for studies of time use in the 20th Century.

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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 65 years of age and older	0.104
Non-metro	Share of resident population living in non-metropolitan areas	0.132
Consumer patents	The stock of patents of consumer goods, trapezoid weights over 26 years	3,262.7
F/(N)	Average household expenditure per person	4,369.5
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
P	The Stone price index	0.556

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)	Appliance input (6)	Transportation input (7)	Recreation input (8)
Constant	0.287	-0.300	0.066	0.254	0.348	0.180	0.131	-0.177
	(0.305)	(0.236)	(0.264)	(0.147)	(0.129)	(0.156)	(0.236)	(0.120)
AGE ≤ 5	0.424	0.184	0.118	-0.008	0.062	0.073	-0.026	-0.053
	(0.157)	(0.125)	(0.144)	(0.087)	(0.080)	(0.093)	(0.146)	(0.075)
AGE ≥65	-0.360	-0.161	-0.240	0.229	0.311	0.025	-0.024	0.021
	(0.282)	(0.223)	(0.261)	(0.146)	(0.131)	(0.155)	(0.243)	(0.122)
Non-metro	-0.056	0.007	-0.065	-0.007	-0.040	0.042	0.030	0.034
	(0.04)	(0.03)	(0.04)	(0.02)	(0.02)	(0.03)	(0.0005)	(0.0002)
ln(Con. patent stock)	0.035	0.032	0.019	0.002	-0.002	0.009	-0.021	0.002
	(0.014)	(0.011)	(0.013)	(0.007)	(0.006)	(0.008)	(0.014)	(0.01)
ln[F/(N)]	-0.034	0.009	-0.011	-0.022	-0.025	-0.018	0.007	0.014
	(0.027)	(0.021)	(0.023)	(0.013)	(0.012)	(0.013)	(0.021)	(0.011)
$\ln P_1$	0.046							
	(0.014)							
$\ln P_2$	-0.028	0.030						
	(0.010)	(0.011)						
$\ln P_3$	0.007	-0.012	0.021					
	(0.007)	(0.006)	(0.008)					
$\ln P_4$	0.003	0.015	0.004	0.002				
	(0.006)	(0.005)	(0.004)	(0.005)				
$\ln P_5$	0.003	0.008	-0.008	-0.004	0.009			
	(0.006)	(0.006)	(0.004)	(0.004)	(0.007)			
$\ln P_6$	0.003	0.004	-0.001	0.004	-0.009	0.002		
	(0.005)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)		
$\ln P_7$	0.005	0.002	-0.003	-0.003	0.007	-0.001	-0.006	
	(0.005)	(0.004)	(0.005)	(0.003)	(0.003)	(0.003)	(0.006)	
$\ln P_8$	-0.002	-0.008	-0.000	0.008	-0.007	-0.000	-0.003	0.009
	(0.005)	(0.005)	(0.003)	(0.003)	(0.004)	(0.003)	(0.002)	(0.004)
R^2	0.996	0.969	0.989	0.707	0.990	0.832	0.874	0.981

[1] System estimated after taking first-differences, which is consistent with $\rho = 1$ 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.

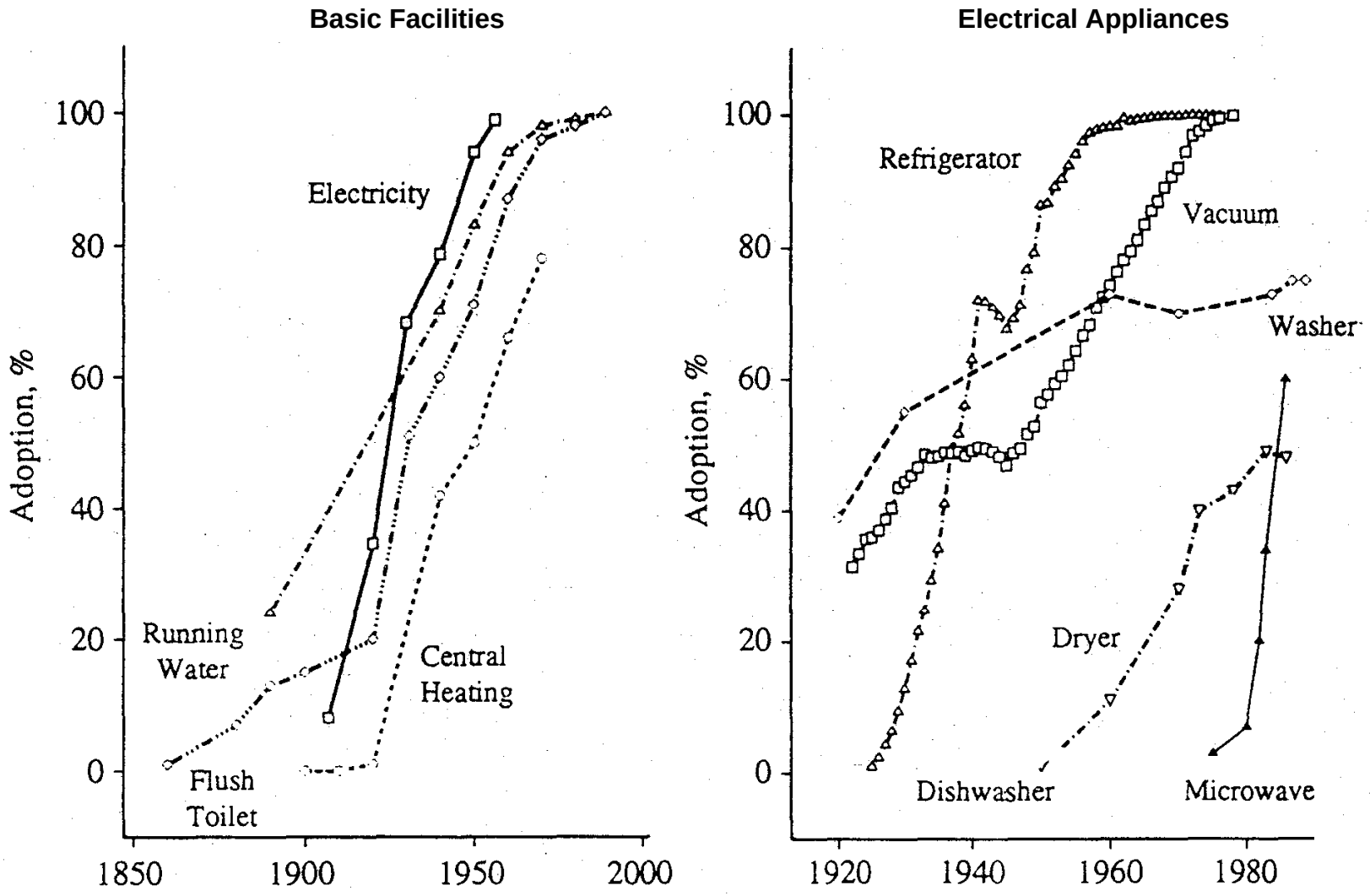
Commodity/Input groups (i)	Prices (j) 1	2	3	4	5	6	7	8	9	Income/ Expenditure Elasticity
	compensated (e^*_{ij})									
1) Women's housework	-0.493	-0.164	0.110	0.043	0.070	0.053	0.085	0.007	0.289	0.713
2) Men's housework	-0.283	-0.489	-0.116	0.229	0.166	0.087	0.077	-0.085	0.414	1.136
3) Food at home	0.253	-0.154	-0.553	0.098	-0.109	0.002	-0.015	0.016	0.587	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	0.113	-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

Table 4. Changes in Women's Housework: 1948-1996

Women's Housework			Change (%)
Actual			-61.8
Due to:			
P_1/P	(-0.493 x 25.8%)[a] =		-12.2
P_2/P	(-0.164 x 18.6%) =	-3.1	
P_3/P	(0.110 x -49.5%) =	-5.5	
P_4/P	(0.043 x 9.6%) =	0.4	
P_5/P	(0.070 x -30.6%) =	-2.1	
P_6/P	(0.053 x -90.1%) =	-4.8	
P_7/P	(0.085 x -22.9%) =	-1.9	
P_8/P	(0.007 x -57.5%) =	-0.4	
P_9/P	(0.289 x 7.1%) =	0.2	
	Subtotal		-17.6
Age < 5 years	(-3.563 x 2.9) =	-10.3	
Age ≥ 65 years	(-3.025 x 4.9) =	-14.8	
Non-metro	(-0.0047 x 7.8) =	-0.0	
	Subtotal		-25.1
Consumer patents	(0.294 x 2.59) =	0.7	
F/NP	(0.713 x 101.2) =	72.1	
	Subtotal		72.8

[a/] The first number in parentheses is the elasticity or partial elasticity of women's housework with respect to a causal factor. The second number is the magnitude of the change of the causal factor from 1948 to 1996.

Figure 1. The Diffusion of Basic Facilities and Electrical Appliances Through the U.S. Economy



Source: Greenwood et al., 2005, p. 111.

Figure 2. Number of Children per 100 Adults, 1920-1996

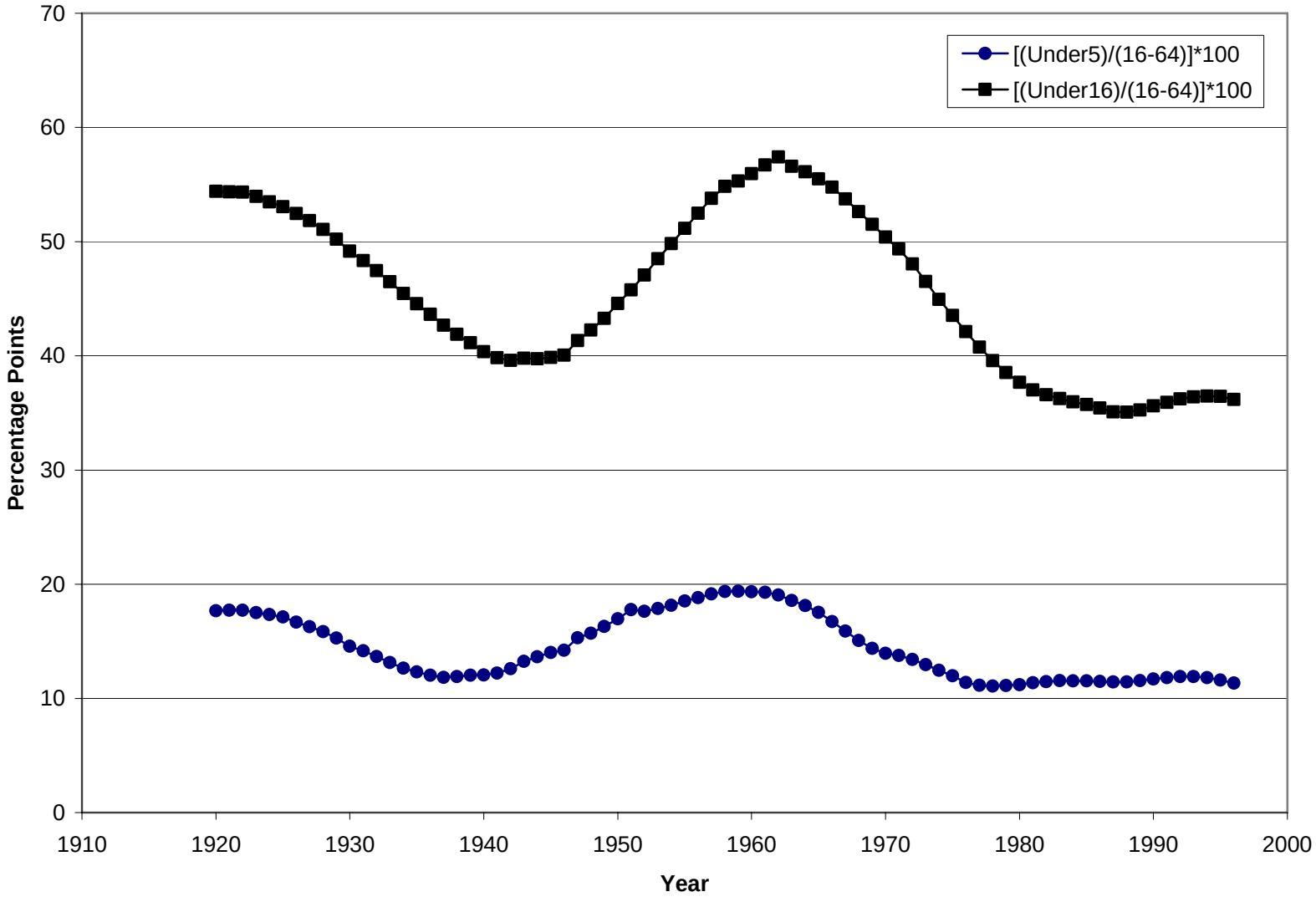


Figure 3. Average Annual Hours of Household Work of Employed and Not Employed Men and Women, Ages 16-64

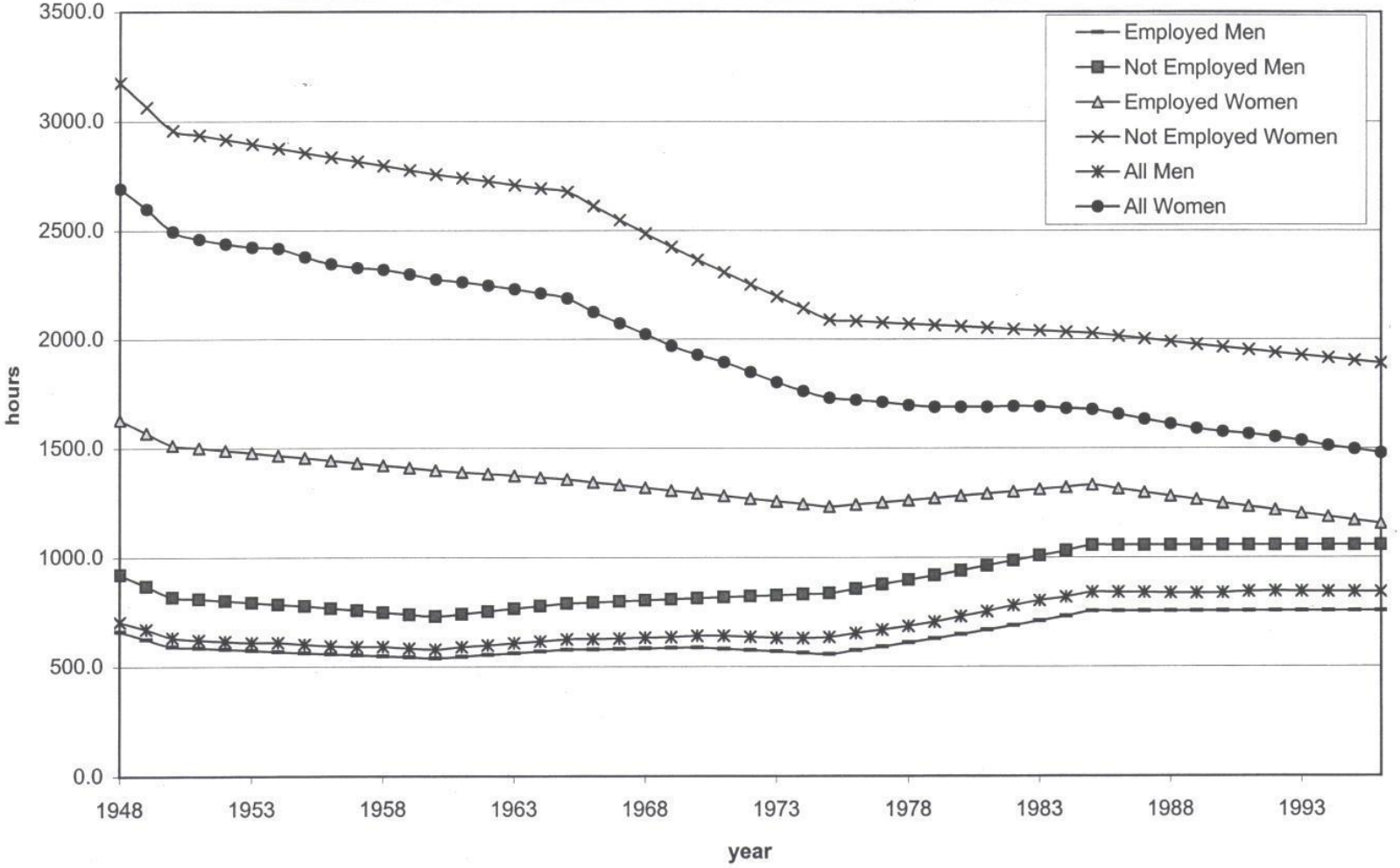


Figure 4. Average Annual Hours of Leisure for Employed and Not Employed Men and Women, ges 16-64

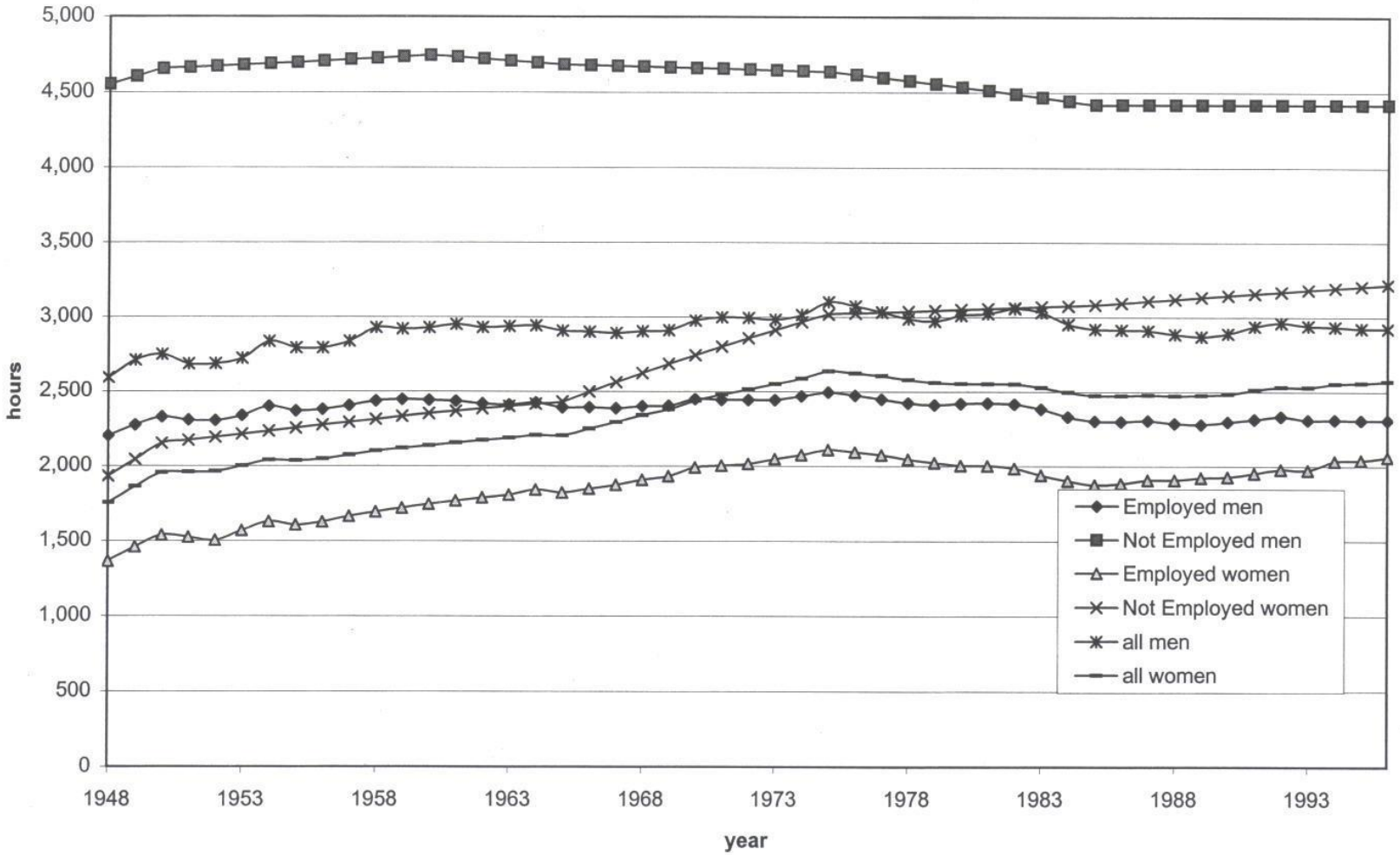


Figure 5. Hourly Opportunity Wage for Employed and Not Employed Men and Women

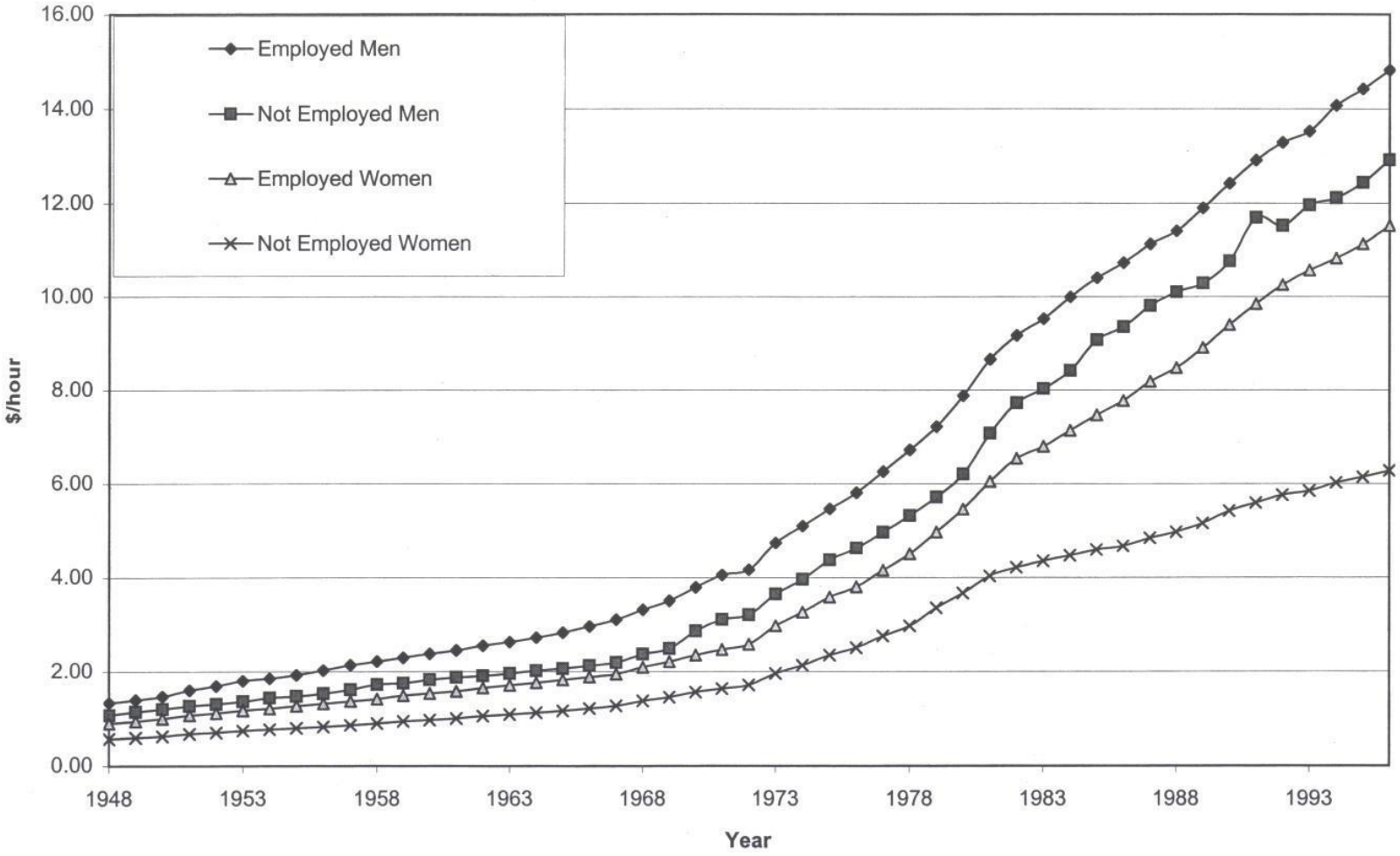


Figure 6. U.S. Household Expenditure Shares, 1948-1996

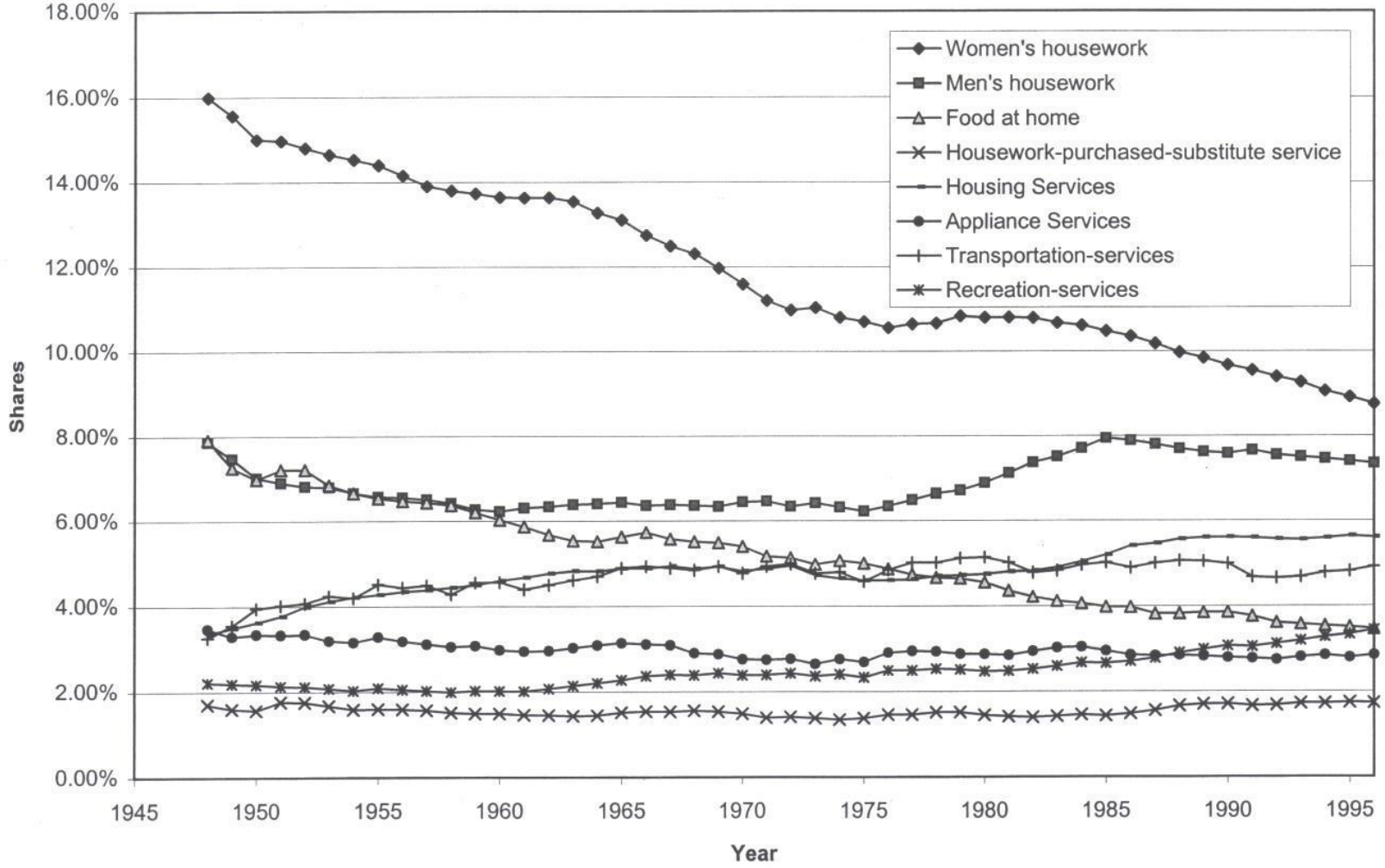


Figure 7. Relative Prices of Inputs for U.S. Household, 1948-1996

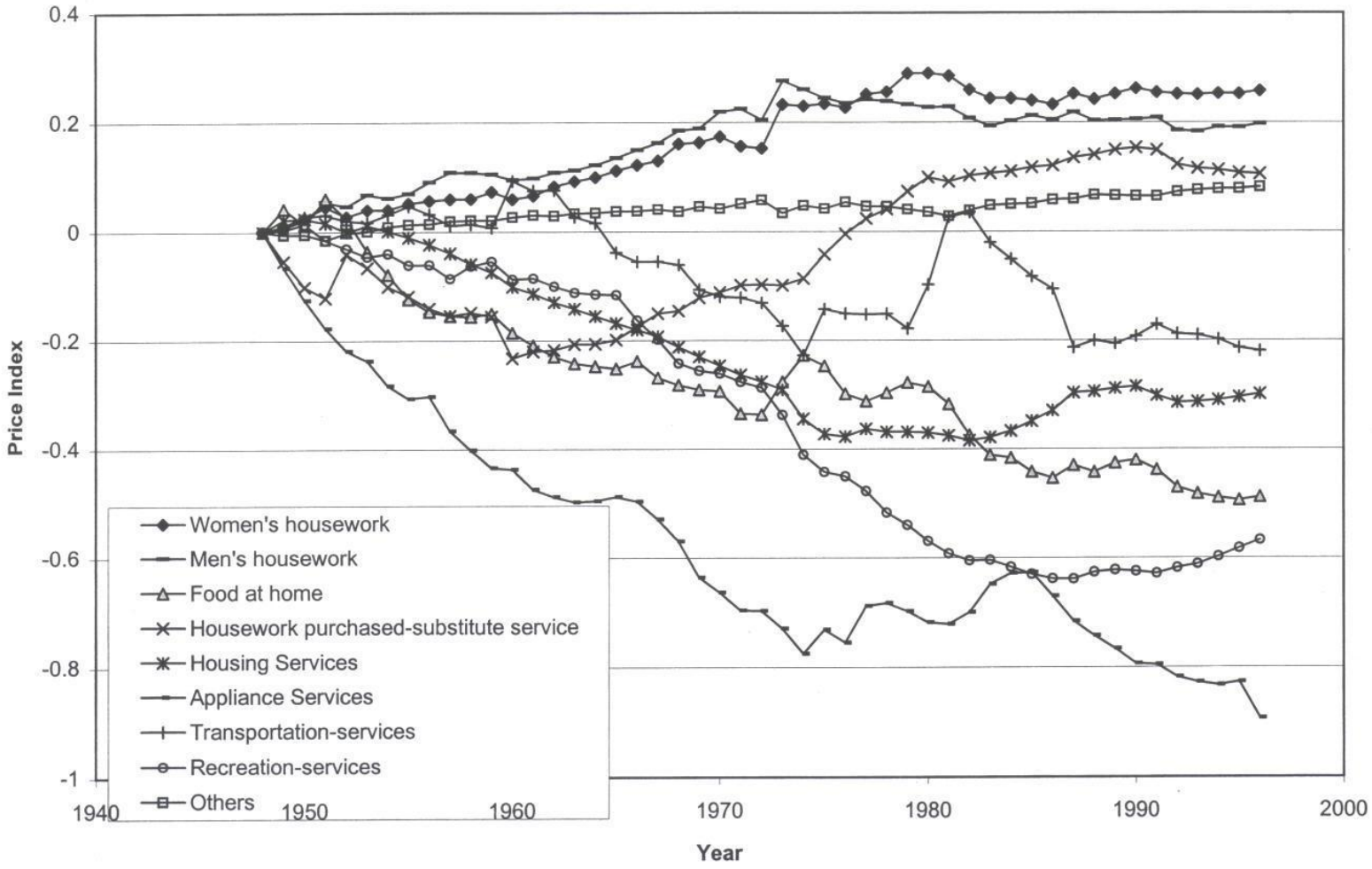
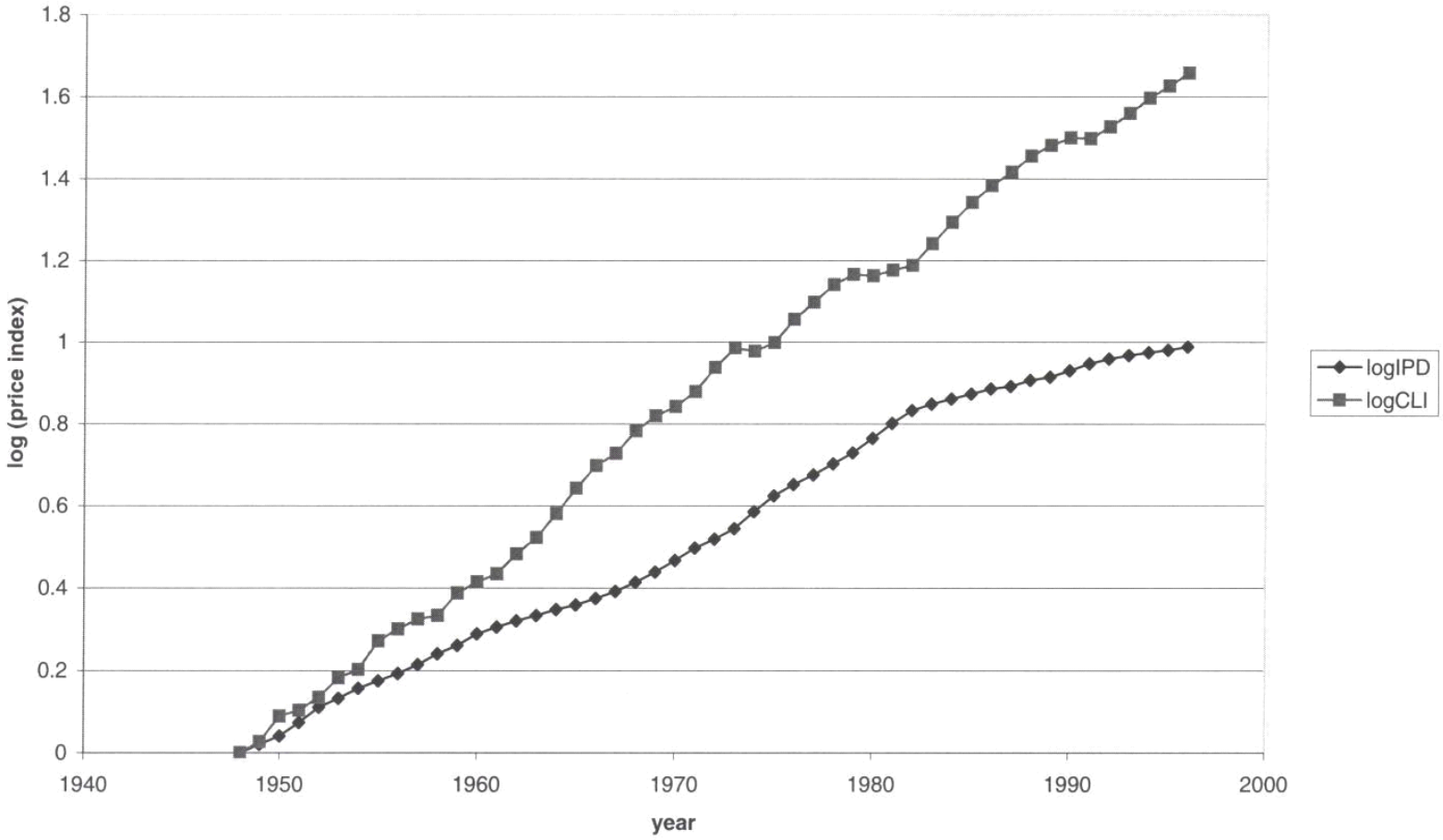
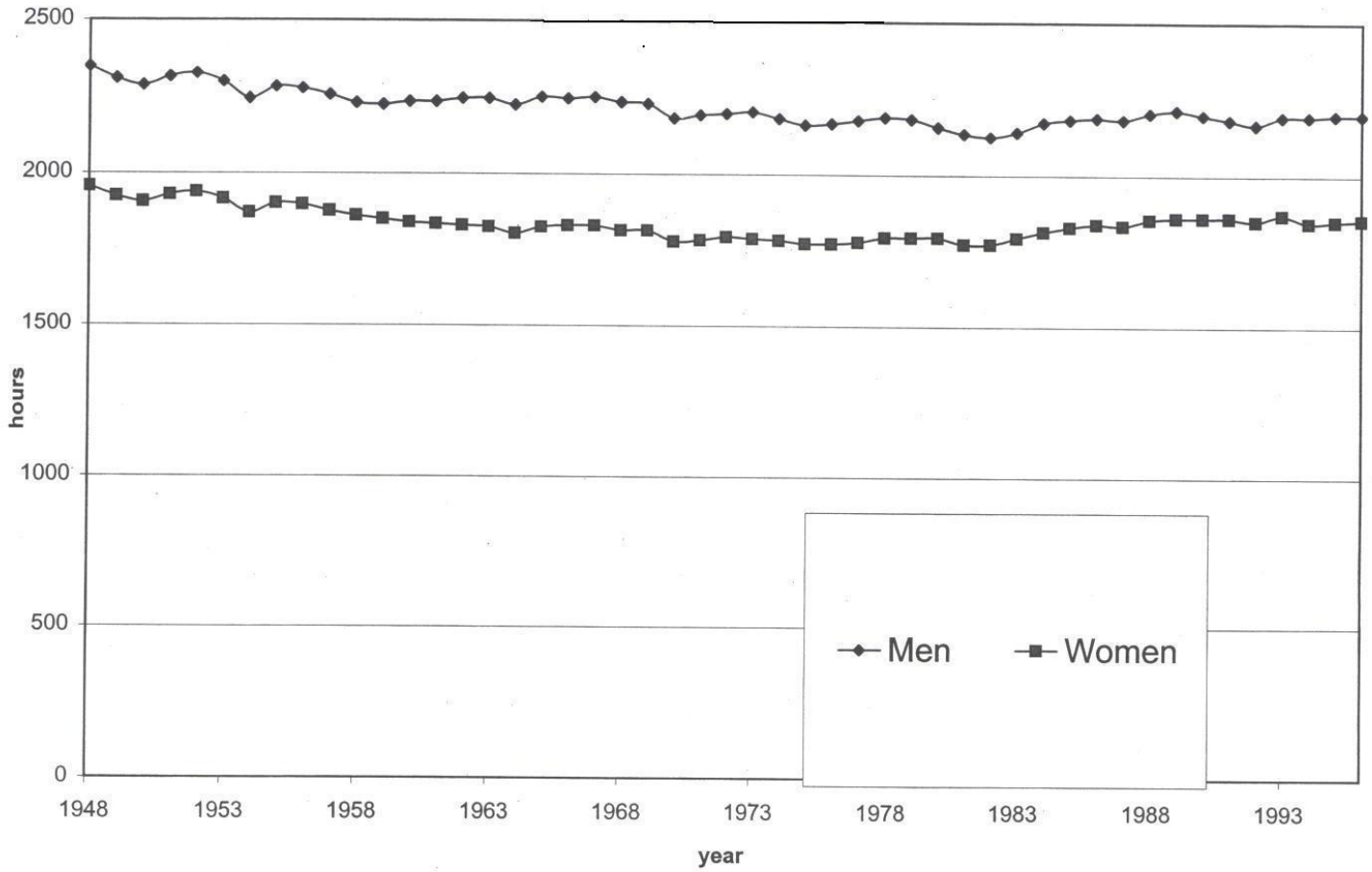


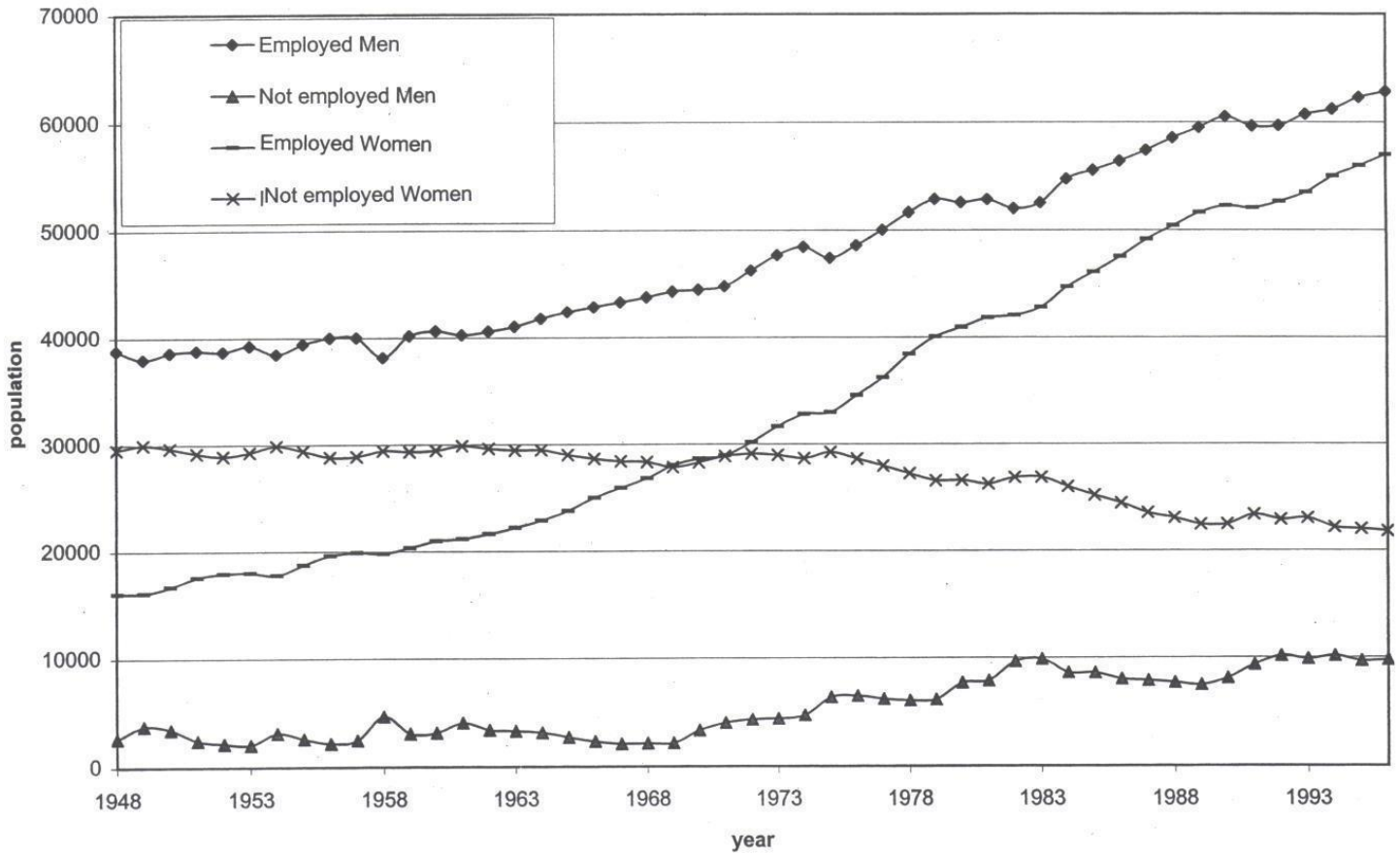
Figure 8. The AIDS Cost of Living Index and Implicit Price Deflator for Personal Consumption Expenditures, 1948-1996



Appendix Figure 1. Annual Hours Worked for Pay of Men and Women 16 Years of Age or Older



Appendix Figure 2. Population of Employed and Not Employed, Ages 16-64



ENDNOTES

[1] For example, Greenwood et al. (2005) use a calibration rather than an econometric model to derive plausible adjustments hours of housework, leisure, and market work in the U.S. household sector over the 20th Century.

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

[3] One can either view that housework contributes to utility by producing commodities that are the ultimate sources of satisfaction (Michael and Becker 1976; Pollak and Wachter 1975).
[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, but the population being sampled contains some heterogeneity over time periods surveyed. This could affect the comparability of their estimates.

[6] 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).

[7] The virtual price concept was developed by Neary and Roberts (1980) for a demand system under rationing. The virtual price p_1^V for the rationed good x_1 at which the consumer optimally and voluntarily chooses the rationed good in a demand system containing non-rationed goods x_2 is $x_1 = x_1^C(U_0, p_1^V, p_2)$. The virtual price is an implicit function of the rationed quantity, prices of the non-rationed goods p_2, and utility U_0. Given the virtual price p_1^V, the Hicksian demand function without rationing is equal to the demand function with rationing: $x_1^{RC}(U_0, p_1, p_2) = x_1^C(U_0, p_1^V, p_2)$. Hence, the virtual price is conceptually sound and widely accepted by consumption and demand theorists. Virtual prices are a device to enlighten the discussion of the likely impact of "missing prices" on the cost of living.

[8] The AIDS is a flexible function form. Other flexible functional forms for a demand system include the translog (Jorgenson and Slesnick 1990) and Rotterdam models. The AIDS and translog are similar (Moschini 1999), but the AIDS is most popular.

[9] Marginal tax rates on income and purchased goods could be incorporated into our economic model of demand for inputs by households. However, in the AIDS, the terms involving the tax rate become a separate variable from the log prices and log income. If the tax rates are roughly constant over time, they will be differenced out of the econometric demand system in the next step. Hence, I choose to exclude explicit treatment of tax terms.

[10] For comparison, the related specification for the standard demand system (without trend) is

$$w_{it} = \alpha_{i0}^{\sim} + \sum_{s=1}^{S} \delta_{is}^{\sim} D_{st} + \sum_{j=1}^{n} \gamma_{ij}^{\sim} \log p_{jt} + \beta_i^{\sim} \log[I_t / P_t(p_{1t}, p_{2t})] + u_{it}^{\sim}.$$

[11] The first-difference transformation of the share equations, however, elevates the relative importance of noise in each equation. Also, including commodity-specific constant terms can detract from the contribution of real per capita expenditures. These identification issues are hard to resolve totally.

[12] We have only one price for men's and one for women's time, and hence, we cannot include leisure time as a separate input. Since leisure time is not the central focus of this study, men's and women's leisure are include in the other input category, and they account for more than 85% of expenditures in this category.

[13] Given that a major activity of households is to bear, care for, and raise children, and roles of men and women are so different in these activities as any parent can verify, we have another reason for keeping men's and women's housework separate.

[14] However, technical change associated with showering/bathing—soaps, shampoos, deodorants, shaving equipment—has made possible steady increases in personal hygiene, with a roughly unchanged average amount of time spent on personal care.

[15] Tendencies to engage in more than one activity at a time, sometimes called joint production or time deepening, are partly reflecting growing scarcity of time, but they are also the source of personal stress and accidents. I stick to primary purposes of time use for allocation purposes.

[16] All computations assume a 365-day and 52-week year.

[17] On average, married women have more hours of housework than non-married women, so this is an overestimate for all women 16-64 who are not in school.

[18] Upgrading home heating equipment from noncentral to central heating was accomplished primarily with the construction of new housing units. The number of new U.S. housing starts during 1920 to 1929 was high by early 20th Century standards, averaging 703 thousand units per year; but they returned to the pre-1920 rate during the Great Depression, Recovery, and World War II years of 1930 to 1947, averaging only 358 thousand per year (U.S. Bureau of Census 1966). The big push on new housing came after the end of World War II, and over 1947 to 1964 the average annual number of new housing starts was at the fantastically high rate of 1.218 million.

[19] The large investment in new housing units over 1947 to 1964 that had technically advanced central heating, piped hot and cold water, soot-free electric lighting (Bryant 1986; Nordhaus 1998, pp. 63) and insulated, relatively tight construction was a major factor permitting women's hours of housework to decline over 1948 to 1965 even in the face of an increasing number of children.

[20] Blau (1998) used the PSID data set for married women and men to derive an estimate of time use in housework in 1978 and 1988. Her estimates of the change in hours of housework over this period are consistent with my data.

[21] Core housework is rated by couples as a less desirable activity in terms of inherent satisfaction than more highly rated activities like child care, but there is with housework—just as with highly rated leisure activities—a complement of time in core housework within married couples (see Hamermesh 2003, and Hallberg and Klevmarken 2003). So while housework is an input and not a leisure activity, it is a type of shared-process benefit activity for married couples. With the aggregate nature of our study, we have, unfortunately, had to abstract from these relationships to make progress.

[22] The existing diary data on housework are of high and variable quality in the samples for the U.S. collected over 1965-1995, e.g., Robinson and Godby. For example, the 1965 data were collected only from a sample of urban households and over a limited age range, the 1985 sample had multiple modes and a low response rate in parts of the sample, and the 1995 data had a small sample size. Yet the long-term trend can be fairly accurately constructed by blending stylized and diary reports of weekly housework, even though the mean estimates might be a little high (see Juster, Ono, and Stafford 2003, p. 40).

[23] Information on time allocation of men and women aged 65 and older are available from the author upon request.

[24] Our estimates of annual average hours of work are consistent with the Census year estimates presented by McGrattan and Rogerson (2004).

[25] Juster and Stafford's estimate for commuting time in 1965 is similar to those of Robinson and Godbey in that year.

[26] I do not include a variable for the share of single parent households or age at first marriage. The rising frequency of female headed households is responding to the gap in wages between men and women, widening labor market opportunities of women and other trend-dominated factors (Goldin 2006). Much of the impact of these variables on input demand will be captured by the male and female wage rates and trend, which are included as regressors in my demand system.

[27] This patent stock index is a proxy for the true household patent stock index. Since we do not have the true index, the inclusion of the proxy will reduce the omitted variables problem (Wooldridge 2002, p. 61-71). The household patent index is a control for disembodies technical change and its inclusion can be expected to improve the quality of the estimated parameters of the other variables in the demand system.

[28] See Costa (2001) for evidence on the U.S. expenditure share on food from personal income in the 20th century.

[29] Since the elasticities are a function of sample information, it does matter where we approximate these elasticities. Also, the housework demand equation is nonlinear in prices, income and translating variables.

[30] This index does not include impacts of changing environmental noise, pollution, or crime, which also impact social welfare. Also, it does not include the welfare improvement to

increasing expected length of life (Nordhaus 2003, Murphy and Topel 2003). However, Nordhaus (2003, pp. 27) shows that these welfare gains were somewhat larger in the first than second half of the 20th Century.

[31] If the comparison was to the CPI, the differences would be even larger. The reasons are that the CPI has fixed beginning period weights, and when the methodology is revised, e.g., in 1983 and again in the late 1990s, the new procedures go forward but not backward. Hence, the reported CPI is not constructed using the same procedures over time.