HOUSEHOLD PRODUCTION, LEISURE AND LIVING STANDARDS

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Abstract

Household production is an important non-market activity and the empirical literature has come up with three main methods towards valuing household production. We follow the literature spawned by Becker (1965), Lancaster (1966) and develop a model of the household as producer and consumer that provides a theoretical justification for the two main approaches towards valuing labour in household production. We provide a justification for the replacement cost approach as a way of valuing labour input into own-account production of households but show also that in general this is an incomplete measure of full consumption. We also develop a cost-of-living index for full consumption and full household income. The consequences of the theoretical model are illustrated by a cross-country comparison, using the data by Ahmad and Koh (2011).

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*Views expressed in this paper are those of the authors and do not necessarily reflect the views of the OECD or its Member countries.

Introduction

Households are economic units that act both as consumers and producers of goods and services. The System of National Accounts (SNA) records mainly those acts of consumption and production that are subject to monetary transactions, leaving out of the picture consumption and production that households undertake on their own account or for other economic units but without a monetary market transaction. In particular, the non-market production of services by households such as cooking or childcare (but not dwelling services provided by owner-occupiers of houses) is outside the SNA production boundary. The reasons why most services produced by households are outside the SNA production boundary are mainly rooted in practical considerations. Absent market prices, it is "[…] therefore extremely difficult to estimate values not only for the outputs of services but also for the associated incomes and expenditures" (2008 SNA paragraph 6.29). At the same time, the SNA acknowledges that for purposes of measuring economic welfare it is useful to estimate the value and evolution of comprehensive household production. The 2009 report of the Stiglitz-Sen-Fitoussi Commission also advocates comprehensive measures of production and consumption and a look at the literature shows that researchers have produced estimates for a number of countries and time periods[1].

Absent market transactions on own-account household production, the question of how to value these services is central. A vast majority of studies has used an input cost approach, valuing outputs by the costs of inputs of which the time household members spend on the task of production is the most prominent element. Two variants of valuing labour have been prevalent: valuation with a market wage rate (the 'opportunity cost approach') and valuation with a wage rate for a household work (the 'replacement cost approach'). The former responds to the question 'What is the earning foregone by the household member due to the fact that he or she produces services at home rather than offering labour services on the labour market?' The latter responds to the question 'How much would it cost to hire some-one on the labour market to produce the household services *in lieu* of the household member?' Hill (2007) summarises the discussion as follows:

> "The procedure adopted in national accounts is to value nonmarket flows of goods and services whenever possible at the prices at which the same goods and services are sold on market. To be consistent with this general principle, the labour inputs should be valued using the market wages payable to employees doing the same kind of work. However, a case can also be made for valuing at internal opportunity costs […] Valuing at internal opportunity costs is not generally favoured in studies on household production, because it makes the value of the labour inputs depend on who does the work, rather than on the nature of the work done. […] A further complication is that people may engage in certain household productive activities, such as child care, because they enjoy it. […] The motivation behind some household activities may be quite complex. For example, the activity or gardening is recognised to be a good form of exercise, so it may be undertaken as a substitute for going to the gym. […] The concept of the opportunity cost in these kinds of circumstances is not altogether clear. On balance, it seems preferable to value work done in household production at the corresponding market wage rate for that type of work." (Hill p. 440).

[1] For valuations of household work see Bridgman, Dugan, Lal, Osborne and Villones (2012); Ahmad and Koh (2011), Roy (2011), Landefeld, Fraumeni and Vojtech (2008), Ruger and Varjonen (2008); Fraumeni (2008); Abraham and Mackie (2005); Landefeld and McCulla (2000); Goldschmidt-Clermont (1993); Folbre and Wagman (1993); Fouquet and Chadeau (1981); Reid (1934); for the valuation of child care more specifically see Folbre and Yoon (2008).

Although the literature has discussed this choice from conceptual and practical perspectives, such a discussion has not been framed in a formal economic model and with a clear distinction between household work as an input into production and household work as a potential source of utility (or disutility) *in itself*. The first contribution of the present paper consists of drawing up such a model and showing how it provides guidance to the valuation issue. We build on Becker's (1965) standard model of household production and conclude that two elements condition the choice between an opportunity cost and a replacement cost approach.

- The first element is whether the household under consideration is constrained in its allocation of time between selling its labour services and other usages of time. If the answer is to the affirmative as would be in the case of an unemployed or retired person, in our present model, the replacement cost method will always constitute the correct valuation for own-account household services.

- In the general case of an unconstrained household, a second element enters considerations: is the purpose of valuing time spent on household production to capture full consumption (a welfare-related concept to gauge living standards) or is the purpose more narrowly defined at capturing only the value of own-account household production (not necessarily a welfare-related concept). In the second case, the replacement cost method applies whereas in the first case, household time should be valued using the opportunity cost method.

(Current price) valuation of non-market activities is but one objective of research in this area. At least as much interest lies in comparing living standards over time or across countries. The evolution of living standards or their comparison across countries is intimately related to the construction of price indices (over time or across countries) that reflect a cost-of-living concept. These price indices are the appropriate vehicle to deflate the nominal values of full consumption. The second contribution of this paper is the development of a cost-of-living index for full consumption in line with our theoretical model.

We conclude by providing some illustrative calculations of full income and household production for a cross-section of OECD countries.

Model

Households that are active on labour markets

Our discussion starts with a household that is unconstrained in its allocation of consumer expenditure and in its allocation of time. In particular, there are no constraints offering labour services on the labour market at the going wage rate. The household consumes the following types of 'commodities': (i) a final consumption product q_1 that is purchased on the market at price p_1 and directly serves to satisfy consumer needs, such as ice cream or a haircut. The product undergoes no transformation by the consumer; (ii) a service Q_N such as washing or child care that the household produces itself[2]. The own-account production process of this service is captured by the production function

[2] The distinction between q_1 and Q_N is not strictly necessary but helpful. In a general set-up such as Becker (1965) and Lancaster (1966), all 'goods' that the household purchases on the market (including 'ice cream') are combined with time or other inputs in a household production function to produce

(1) $Q_N=f_N(t_N+q_N, q_2)$

where t_N stands for the time the household spends on producing the service. We assume that instead of spending time on production, the household can also hire labour q_N that is perfectly substitutable to t_N as in input[3]. q_2 is the quantity of intermediate inputs and/or capital services from consumer durables used in production. f_N will be taken to be an increasing, concave and linearly homogenous function of t_N+q_N and q_2 over suitable domains of definition. An important and rather restrictive assumption is implicit in (1): the absence of disembodied productivity growth in the production of household services[4].

Turning to the household's time constraint, we let T be the total time per period available to the household, after accounting for matters of personal care. T can then be either spent on t_L hours of work in the labour market, t_N hours of work in own-account production or t_F hours of leisure so that

(2) $T = t_L+t_N+t_F.$

Next we specify the household's utility function as $U(q_1,Q_N,t_L,t_F,t_N)$. U contains the items that the household 'consumes' and values positively or negatively. In particular, U will be taken as a concave function, that is increasing in q_1, Q_N, and t_F, of unknown sign[5] in t_N, and decreasing in t_L. Explicit appearance of the time variable in the utility function allows for situations where households are not indifferent between spending time on household work, market work or leisure above and beyond the fact that they generate consumption possibilities. Thus, in addition to serving as an input into own-account production, the household also 'consumes' t_N directly. For example, time spent with a child not only constitutes an input to the service 'child care' but may be valued *as such* by households. Along a similar vein, the household 'consumes' leisure t_F – that is the time not spent on paid work, on household work and on personal care. This point had already been made by Pollak and Wachter (1975) who argue in favour of keeping separate time variables in the utility function

> "In particular, we object to the implied but crucial assumption that time spent cooking and time spent cleaning are 'neutral' from the standpoint of the household and that only the 'outputs' of these production processes enter the household's utility function. A more plausible assumption is that the household is not indifferent among all situations which involve the same output of home cooked meals and clean houses but involve different amounts of hired labor and household labor. Instead, we suggest that household time spent cooking or cleaning is a direct source of utility or disutility to the household." (Pollak and Wachter, 1975, p. 270).

'commodities'. In this sense, our q_1 commodity is a special case where intermediate inputs coincide with the final service produced by the household.

[3] This is a simplification. The empirical literature (see for instance Abraham and Mackie 2005) has discussed whether one hour spent by a household to accomplish a particular task such as plumbing equals one hour spent on the same task by a professional. In many cases, the answer will be 'no', and a quality adjustment will be required. This is easy to introduce into the theoretical model but hard to estimate in practice.

[4] As with the case of quality adjustment of labour input spelled out in the preceding footnote, ignoring productivity change is in anticipation of the empirical problems associated with its estimation rather than a reflection of introducing productivity change into the theoretical model.

[5] We shall, however, assume monotonicity so that the derivative is non-decreasing or non-increasing everywhere over the domains of interest.

Before going further note two further shortcuts in the present formulation. The first shortcut consists in the use of scalars for each type of commodity. Obviously, in reality we shall be dealing with vectors of final consumption products, and several types of own-account produced services. An extension from scalars to vectors is fairly straight forward but comes at the expense of more complicated notation which we want to avoid at this stage. The second shortcut is empirically motivated and lies in our labelling of Q_N as a service. In practice, households produce not only services but also goods for their own account. The empirical difference is that own-account produced goods *are* included in countries' national accounts whereas own-account produced services (with the exception of own-produced dwelling services) are outside the national accounts production boundary and so do not figure in data on private consumption. As all conceptual considerations regarding own-account production of services that will follow carry over directly to own-account produced goods we chose to restrict ourselves to the discussion of services because they are both produced on own account and outside the conventional measurement boundary. This is without consequences for the theoretical exposition.

Having dealt with consumption commodities and own-account production, we now come to consumption expenditure, monetary transactions and income. Note the difference between consumption and consumption expenditures that arises in the present context. Hill (2009) explains this as follows:

"In the present context, it is necessary to underline the fundamental distinction between consumption and consumption expenditures, even though the two terms are often casually used interchangeably […] Household final consumption is a particular type of economic activity in which members of households use goods or services to satisfy their personal needs, wants or desires. By definition, a final consumption good or service provides utility to the person or household that consumes it. […] Household consumption expenditures may be defined as expenditures incurred by households to *acquire* goods and services that they intend to use for purposes of final consumption." (Hill, p.432).

In our set-up, the household's consumption expenditure consists of (i) final consumption goods q_1, purchased at price p_1; (ii) intermediate products q_2, purchased at price p_2; (iii) labour services q_N, purchased at price w_N; (iv) consumer durables. Consumer durables are capital goods that deliver capital service above and beyond the period during which they are purchased. Although the national accounts, in principle, recognise the capital character of consumer durables, by convention, they are treated as final goods, that is, as if they were consumed during the period of purchase. This convention cannot be sustained in a model of household production, and for empirical purposes, we shall construct a stock of consumer durables that delivers capital services to household production. The formal model can easily capture capital services as a particular version of q_2. Also, in the special case where all consumer durables are rented, the capital services become intermediate inputs. Our conceptual considerations will therefore be limited to q_1, q_2, and q_N.

To define household consumption and consumption expenditure in our set-up, we start by stating the monetary budget constraint that the household faces. Let w be the household's wage rate on the labour market, so that wage income is given by wt_L. Let Y stand for all other forms of money revenues (for instance property income), and abstract from net lending (or suppose that this is also captured by Y), then the monetary budget constraint faced by the household (and pictured in the national accounts) indicates that households' disposable income equals consumption expenditure:

$$(3) \qquad wt_L + Y = p_1q_1 + p_2q_2 + w_Nq_N.$$

Substituting the time constraint into the monetary budget constraint yields the following extended budget constraint

(4) $w(T-t_N-t_F)+Y = p_1q_1+p_2q_2+w_Nq_N$ and further

(5) $FI \equiv wT+Y = p_1q_1+p_2q_2+w_Nq_N+wt_N+wt_F$

The left-hand side of (5) now shows a *nominal* measure of *full income* $FI \equiv wT+Y$. The first term in this full income expression is total time available to the household, T, which has been valued with the household's labour market wage rate w. Becker (1965) reasons as follows:

> "Households in richer countries do, however, forfeit money income in order to obtain additional utility, i.e., they exchange money income for a greater amount of psychic income. For example, they might increase their leisure time, take a pleasant job in preference to a better-paying unpleasant one, employ unproductive nephews or eat more than is warranted by considerations of productivity. In these and other situations the amount of money income forfeited measures the cost of obtaining additional utility. Thus the full income approach provides a meaningful resource constraint and one firmly based on the fact that goods and time can be combined into a single overall constraint because time can be converted into goods through money income. It also incorporates a unified treatment of all substitutions of non-pecuniary for pecuniary income, regardless of their nature or whether they occur on the job or in the household." (Becker 1965, p. 498)

The right-hand side of (5) shows a measure of consumption of the consumer-producer household. In what follows, we shall refer to the sum of direct consumption, the value of intermediate products, work at home, hired labour services and leisure as *full consumption* $FC \equiv p_1q_1+ p_2q_2+w_Nq_N+wt_N +wt_F$.

To make a statement about the valuation of the different components of household time, it will be necessary to move from definitional relationships to behavioural relationships. We start by using the time constraint to eliminate t_L from the utility function and define a reduced form utility function f as

(6) $f(q_1, Q_N, t_F, t_N) \equiv U(q_1, Q_N, t_F, t_N, T-t_N-t_F)$.

The household's maximisation problem is then

(7) $\max_{q_1,q_2,q_N,t_N,t_F} \{f : p_1q_1 + p_2q_2 + w_Nq_N + wt_F + wt_N \leq FI;\ Q_N=f_N(t_N+q_N, q_2)\}$.

In words, households maximise utility given their monetary and time budget constraints and given a technology for the production of own-account household services. Assume that q_1^*, q_2^*, q_N^*, t_F^* and t_N^* are positive and solve (7). With a monotonicity condition on the utility function f, the budget constraint will hold with equality so one has $p_1q_1^*+ p_2q_2^*+ w_Nq_N^*+wt_N^*+wt_F^*=FI=FC$. The first order conditions for a utility maximum are

(8) $\lambda^* p_1 = \partial f^*/\partial q_1$;

(9) $\lambda^* p_2 = [\partial f^*/\partial Q_N][\partial f_N^*/\partial q_2]$;

(10) $\lambda^* w = [\partial f^*/\partial Q_N][\partial f_N^*/\partial t_N] + \partial f^*/\partial t_N$;

(11) $\lambda^* w_N = [\partial f^*/\partial Q_N][\partial f_N^*/\partial q_N]$;

(12) $\lambda^* w = \partial f^*/\partial t_F$;

where f_N^* and f* denote functions evaluated at the utility-maximising variables and λ^* is the corresponding marginal utility of income. We can now interpret the conditions for utility-maximising

behaviour. From (12) it is clear that a household that is not constrained in its supply of hours to the labour market, the implicit price of leisure is its opportunity cost or the hourly market wage rate w: households will adjust leisure time until the marginal utility from leisure ($\partial f^*/\partial t_F$) equals the marginal utility from offering an extra hour of paid work at the rate w. Comparison of (10) and (12) indicates that time will be allocated to leisure and household work such that, at the margin, they yield the same utility.

Next consider (10) and (11) – they inform about the implicit price for time spent on household production t_N and on the optimal hiring of household labour q_N. (10) indicates that the total shadow price of time spent in household work is the market wage w. But remember that t_N is a joint product that is both an input into household production and a 'commodity' in itself (it constitutes an argument in the utility function), and consequently the total shadow price of t_N has two components as can be seen from the right hand side of (10). The first component is the shadow price of t_N as an input into household production, the second component is the shadow price of the 'commodity' t_N. As t_N and q_N are perfect substitutes, it must be true that the marginal product of t_N just equals the marginal product of q_N: $[\partial f^*/\partial Q_N][\partial f_N^*/\partial t_N] = [\partial f^*/\partial Q_N][\partial f_N^*/\partial q_N]$. Inserting this equality into (10) and (11) tells us that the shadow price of the 'commodity' t_N is $(w-w_N)$, and consequently, the shadow price of household labour as production input is w_N:

(13) $\lambda^* w_N = [\partial f^*/\partial Q_N][\partial f_N^*/\partial t_N]$.

This provides a theoretical justification for the common practice of valuing household work *as an input into household production* by the wage rate of a comparable household employee. Note, however, that this remains a partial approach – when welfare-relevant full consumption is to be valued, comprising all aspects of t_N (as well as leisure) the correct price for an unconstrained household is w.

The shadow price of the 'commodity' t_N is:

(14) $\lambda^*(w-w_N) = \partial f^*/\partial t_N$.

This expression determines the allocation of time worked at home. If there is negative marginal utility to housework so that $\partial f^*/\partial t_N<0$, a necessary condition for an interior solution, i.e., a positive supply of t_N, is $w-w_N<0$: it implies that the opportunity cost of housework is less than the cost of hiring someone to provide household labour services. If w were larger than w_N, no time would be spent on household work. Conversely, if the marginal utility from household work is positive ($\partial f^*/\partial t_N>0$) a necessary condition for an interior solution is that w exceeds w_N. Thus, the household will increase time worked at home even if the market wage that it could earn is higher than the costs of hiring a domestic employee as long as the difference between w and w_N (in utility terms) is smaller than the direct utility derived from working at home. For example, a person may be willing to take care of a child even if the wage foregone on the labour market exceeds the costs of hiring a nanny. One can think of corner solutions where either no or a maximum amount of t_N is supplied. A corner solution will arise in particular when household labour is not an argument in the utility function but *only* an input into household production. In this case, all household work will be carried out by the household itself ($t_N>0$, $q_N=0$) if the wage rate of domestic labour exceeds the household's wage rate on the labour market ($w_N>w$) and the correct valuation of t_N is the market wage rate w. In the opposite case of ($w_N<w$) there would be no time spent on household production ($t_N=0$, $q_N>0$) and the issue of valuation of t_N does not arise. However, such corner solutions are only of moderate empirical interest and we have therefore focused on interior solutions.

Having established that the implicit price of t_N in its usage as an input into producing Q_N is w_N, we can take a closer look at the household's own account production function (1). In particular, we are

interested in defining an implicit price of the own-account product Q_N, given that in practice it will rarely be possible to directly observe such a price. Define the cost function that is dual to this production function as follows:

$$(15) \qquad C_N(Q_N,w_N,p_2,) \equiv \min_{q_2,q_N,t_N} \{w_N(t_N+q_N)+p_2q_2 : f_N(t_N+q_N,q_2) \geq Q_N\}$$
$$= Q_N C_N(1,w_N, p_2)$$
$$= Q_N P_N.$$

In the first line of (15), we have made use of (11) that establishes the input price of t_N. The second equation follows from the linear homogeneity of f_N; that is, total cost is equal to total output times unit costs $C_N(1,w_N,p_2)$, where the latter are independent of the level of production/consumption Q_N. For the third equation, the implicit price of own account production has been defined as its unit cost: $P_N \equiv C_N(1,w_N, p_2)$. For utility-maximising levels of household production, Q_N^*, one gets

$$(16) \qquad C_N(Q_N^*,w_N, p_2) = Q_N^* C_N(1,w_N,p_2) = w_N(t_N^*+q_N^*)+p_2q_2^*.$$

Multiplication of both sides of (9) by q_2^*, of both sides of (11) by q_N^* and of both sides of (14) by t_N^* gives

$$(17) \qquad \lambda^* p_2q_2^* + \lambda^* w_N(t_N^*+q_N^*) = (\partial f^*/\partial Q_N)[(\partial f_N^*/\partial q_2)q_2^* + (\partial f_N^*/\partial t_N)(t_N^*+q_N^*)]$$
$$= (\partial f^*/\partial Q_N)Q_N^* \qquad \text{using the linear homogeneity of } f_N.$$

Next, combine (17) and (16):

$$(18) \qquad \lambda^*[p_2q_2^* + w_N(t_N^*+q_N^*)] = \lambda^* Q_N^* C_N(1,w_N,p_2)$$
$$= \lambda^* Q_N^* P_N = (\partial f^*/\partial Q_N)Q_N^* \text{ and } \lambda^* P_N = (\partial f^*/\partial Q_N).$$

The last line of the expression above suggests that the implicit price P_N, defined above as the unit cost of producing Q_N, is indeed the shadow price of household production: P_N (times the marginal utility of income λ^*) equals the marginal utility that households derive from own-account services Q_N^*.

The final step towards deriving measures of full income and full consumption is accomplished by invoking minimum expenditure of the consumer/producer's activity. Formally, we capture the cost side by an expenditure function e that is dual to the utility function f. Note that we use (14) to put a shadow price to the 'commodity' t_N that directly shows up in the utility function.

$$(19) \qquad e(u^*,p_1,P_N,w,w_N) \equiv \min_{q_1,q_2,q_N,t_N,t_F} \{p_1q_1 + P_NQ_N + (w-w_N)t_N + wt_F : f(q_1,Q_N,t_F,t_N) \geq u\}.$$

Under the regularity conditions imposed on f, actual expenditure equals minimum expenditure so that $e(u^*,p_1,P_N,w,w_N)=FC=FI$. Here, u^* is the utility level commensurate with the cost-minimising choice of q_1^*, Q_N^*, t_F^* and t_N^*, given prices p_1, P_N, w_N and w. Thus

$$(20) \qquad e(u^*,p_1,P_N,w,w_N) = p_1q_1^* + P_N^* Q_N^* + (w-w_N)t_N^* + wt_F^*$$
$$= p_1q_1^* + p_2q_2^* + w_Nq_N^* + wt_N^* + wt_F^* \qquad \text{by using (18)}$$
$$= FC = FI.$$

t_N^* is valued at its shadow price, so in considering full consumption and substituting $P_N^* Q_N^*$ for $p_2q_2^* + w_Nq_N^* + w_Nt_N^*$, we end up with wt_N^* as the value of time spent on household work. We can now draw some conclusions concerning the case of an unconstrained household:

- In the absence of corner solutions, the replacement cost approach is the relevant valuation of time spent on household work *as in input into producing the own-account service* Q_N. This lends support to many studies that have proceeded along these lines.

- The opportunity cost valuation is, however, the appropriate approach towards valuing time spent on household labour when the objective is valuing *full consumption*, above and beyond household production Q_N. Full consumption also captures the value of t_N as a commodity and leisure, lending a welfare interpretation to time allocated by the household. Leisure should be valued with an opportunity cost approach.

Households that are not active on labour markets

To this point, we have dealt with a representative household that is free in its choice of allocating income and time between different uses. While this may be true for some households it is certainly not true for all households. We therefore examine now the part of the population that is not active on the labour market due to some institutional or economic constraint – compulsory retirement age, or unemployment come to mind – and study the consequences for the valuation of household time. We start with a general utility function $U(q_1,Q_N,t_F,t_N)$ from which the labour supply variable has been eliminated since it is fixed at zero. As before, U is increasing in q_1, Q_N, t_F, and either decreasing or increasing in t_N. Nothing changes with regard to the production function f_N. The new time constraint is

(21) $t_F + t_N = T.$

Absent labour market income, the new household budget constraint is:

(22) $Y = p_1q_1 + p_2q_2 + w_Nq_N.$

t_N can be eliminated from the utility function using the time constraint (21) so as before we define a *reduced form utility function*, F:

(23) $F(q_1,Q_N,t_F) \equiv U(q_1,Q_N,t_F,T-t_F).$

The consumer's utility maximization problem can be written as follows:

(24) $\max_{q_1,q_2,q_N,t_F} \{F : p_1q_1 + p_2q_2 + w_Nq_N \leq Y;\ Q_N=f_N(t_N+q_N,\ q_2)\}.$

As before we assume that q_1^*, q_2^*, q_N^* and t_F^* are all positive and solve (24). With a monotonicity condition on the utility function F, the budget constraint will hold with equality so we will have $p_1q_1^* + p_2q_2^* + w_Nq_N^* = Y$. When F is differentiable, the first order necessary conditions are:

(25) $\lambda^* p_1 = \partial F^*/\partial q_1;$

(26) $\lambda^* p_2 = [\partial F^*/\partial Q_N][\partial f_N^*/\partial q_2];$

(27) $\lambda^* w_N = [\partial F^*/\partial Q_N][\partial f_N^*/\partial q_N];$

(28) $0 = -[\partial F^*/\partial Q_N][\partial f_N^*/\partial q_N] + \partial F^*/\partial t_F.$

Expression (28) describes the choice between own-account production and leisure: at the margin, the utility from producing extra own-account output Q_N by spending an additional hour on household work has to equal the marginal utility from extra household work as a commodity minus the marginal utility lost by sacrificing an hour of leisure. The latter two effects are captured by $\partial F^*/\partial t_F$ (assumed to be non-negative, otherwise we would face a corner solution with all time allocated to household production). Adding (27) and (28) gives us the following equation:

(29) $\lambda^* w_N = \partial F^*/\partial t_F$.

Equation (29) tells us that the shadow price of leisure, t_F, is now equal to w_N, the market price for purchased labour services. As noted earlier, $\partial F^*/\partial t_F$ is a net effect, combining the direct effects of leisure on utility and the direct effects on utility of the change in t_N, that is necessarily associated with the time constraint (21). Since $\partial f_N^*/\partial q_N$ equals $\partial f_N^*/\partial t_N$, equation (27) implies also that

(30) $\lambda^* w_N = [\partial F^*/\partial Q_N][\partial f_N^*/\partial t_N]$.

Thus, for a constrained household, the correct valuation of the labour input into household production is the replacement cost method. Now multiply both sides of (26) by q_2^*, both sides of (27) by q_N^*, both sides of (30) by t_N^* to obtain the following equation:

(31) $\lambda^*[p_2 q_2^* + w_N q_N^* + w_N t_N^*]$
$= [\partial F^*/\partial Q_N][(q_N^* + t_N^*)(\partial f_N^*/\partial q_N) + q_2^*(\partial f_N^*/\partial q_2)]$
$= [\partial F^*/\partial Q_N]\, f_N^*$ using the linear homogeneity of f_N
$= [\partial F^*/\partial Q_N]\, Q_N^* = \lambda^* P_N^* Q_N^*$. using (1) and (18).

There is no difference between the constrained and the unconstrained household as far the household's production function and cost function is concerned. Thus, it is still the case that P_N, the implicit price of own-account production, equals unit costs of household production. From equations (25), (15) and (29) it can be seen that the three first order partial derivatives of $F(q_1^*, Q_N^*, t_F^*)$ are proportional to the prices p_1, P_N^* and w_N and we have:

(32) $E(u^*, p_1, P_N, w_N)$
$= p_1 q_1^* + P_N^* Q_N^* + w_N t_F^*$
$= p_1 q_1^* + p_2 q_2^* + w_N q_N^* + w_N t_N^* + w_N t_F^*$ using (15),

where E is the expenditure function that is dual to the utility function $F(q_1, Q_N, t_F)$. Finally, along with (22), the two equations in (32) imply the following

(33) $p_1 q_1^* + P_N Q_N^* + w_N t_F^* = Y + w_N t_N^* + w_N t_F^*$
$= Y + w_N T$ using the time constraint (21)

where the last expression is again nominal full consumption and full income, except that we are using the wage rate for market home services w_N in place of the opportunity market wage rate as was the case for an unconstrained household.

We conclude that in the case of a constrained household:

- In the absence of corner solutions, the replacement cost approach is the relevant valuation of time spent on household work *as in input into producing the own-account service* Q_N. There is thus no difference to the case of an unconstrained household;

- Unlike unconstrained households, however, the replacement cost valuation is also the appropriate approach towards valuing time spent on household labour when the objective is valuing full consumption, above and beyond Q_N. Full consumption also captures the value of t_N as a commodity and leisure, both of which are valued with replacement costs in the case of a constrained household.

Cost-of-living index

This is not the end of the story, however. Two analytical questions are now of interest. First, given the value of full consumption, how should its movements be split into a price and a volume component? And second, is the associated price index a cost-of-living index? This is important because a cost-of-living index is the conceptually appropriate tool for deflation of consumption or income flows when making inter-temporal or inter-spatial welfare-based comparisons of standards of living.

A cost-of-living index gauges the relative cost of achieving the same level of utility when households face different sets of prices for the components of full consumption. For a single type of household, the Konüs (1924) cost-of-living index is defined as the ratio of two expenditure functions, each evaluated at price vectors for the comparison periods and for a reference set of utility levels. For the purpose at hand, we have two types of households, and need to develop a group cost-of-living index. We start by simplifying our notation and define the following vectors.

(34) $\mathbf{u} \equiv [u_a, u_p, n_a, n_p]$

$\mathbf{P}_a \equiv [p_1, P_{N,a}, w_N, w]$; $\mathbf{P}_p \equiv [p_1, P_{N,a}, w_N]$;
$\mathbf{Q}_a \equiv [q_{1,a}, Q_{N,a}, t_{N,a}, t_{F,a}]$; $\mathbf{Q}_p \equiv [q_{1,p}, Q_{N,p}, t_{N,p}+t_{F,p}]$;

$\mathbf{p}_a \equiv [p_1, p_2, w_N, w]$; $\mathbf{p}_p \equiv [p_1, p_2, w_N, w_N]$;
$\mathbf{q}_a \equiv [q_{1,a}, q_{2,a}, q_{N,a}, t_{N,a}+t_{F,a}]$; $\mathbf{q}_p \equiv [q_{1,p}, q_{2,p}, q_{N,p}, t_{N,p}+t_{F,p}]$.

The subscripts 'a' and 'p' stand for the 'active' and non-active ('passive') part of the population with regard to their involvement in the labour market. Vectors in upper case letters indicate prices and quantities including the (often unobserved) prices and quantities of household production. Vectors in lower case letters indicate prices and quantities including the (typically observable) prices and quantities of the inputs into household production. n_a and n_p is the number of active and inactive households, respectively. Combine the expenditure functions of the active and non-active households developed earlier into an aggregate expenditure function ε by weighting each expenditure function by the number of households:

(35) $\varepsilon(\mathbf{u}, \mathbf{P}_a, \mathbf{P}_p) \equiv n_a e(u_a, \mathbf{P}_a) + n_p E(u_p, \mathbf{P}_p)$.

We then follow Pollak (1980) and Diewert (1983) and call P* a plutocratic cost-of-living index between period 1 and period 0:

(36) $P^*(\mathbf{u}, \mathbf{P}_a^0, \mathbf{P}_p^0, \mathbf{P}_a^1, \mathbf{P}_p^1)$
$\equiv \varepsilon(\mathbf{u}, \mathbf{P}_a^1, \mathbf{P}_p^1)/\varepsilon(\mathbf{u}, \mathbf{P}_a^0, \mathbf{P}_p^0)$

In (36), the price index P^* is the ratio of the minimum expenditure of the two groups of households, given prices in period 1 and in period 0, and given reference utility measures and household numbers **u**. Time periods have been indicated via superscripts. Diewert (1983, 2001) shows how the Laspeyres and the Paasche-type index form the upper and the lower bound of the true group price index P*. The Fisher index constitutes the point estimate for the change in cost of living:

(37) $P^*(\mathbf{u}^0, \mathbf{P}_a^0, \mathbf{P}_p^0, \mathbf{P}_a^1, \mathbf{P}_p^1)$
$\leq \sum_{j=a,p} n_j \mathbf{P}_j^1 \cdot \mathbf{Q}_j^0 / \sum_{j=a,p} n_j \mathbf{P}_j^0 \cdot \mathbf{Q}_j^0$
$= \sum_{j=a,p} n_j \mathbf{p}_j^1 \cdot \mathbf{q}_j^0 / \sum_{j=a,p} n_j \mathbf{p}_j^0 \cdot \mathbf{q}_j^0 \equiv P_L^*$ using (20);

(38) $P^*(\mathbf{u}^1, \mathbf{P}_a^0, \mathbf{P}_p^0, \mathbf{P}_a^1, \mathbf{P}_p^1)$

$\geq \sum_{j=a,p} n_j \mathbf{P}_j^1 \cdot \mathbf{Q}_j^1 / \sum_{j=a,p} n_j \mathbf{P}_j^0 \cdot \mathbf{Q}_j^1$

$= \sum_{j=a,p} n_j \mathbf{p}_j^1 \cdot \mathbf{q}_j^1 / \sum_{j=a,p} n_j \mathbf{p}_j^0 \cdot \mathbf{q}_j^1 \equiv P_L^*$ using (32);

(39) $P_F = (P_L^* P_P^*)^{0.5}$.

P_F^* provides the price change that is required to break down the value change of full consumption into a price and a volume component. Thus, by applying the Fisher price index P_F^* to the measure of full consumption as defined earlier, we obtain a Fisher *volume index Q_F of full consumption*:

(40) $Q_F \equiv [FC^1 / FC^0]/P_F$,

where $FC^0 = \sum_{j=a,p} n_j \mathbf{p}_j^0 \cdot \mathbf{q}_j^0$ and $FC^1 = \sum_{j=a,p} n_j \mathbf{p}_j^1 \cdot \mathbf{q}_j^1$.

This completes our theoretical considerations concerning the valuation of household work and leisure as well as the measurement of full consumption in real terms over time and across countries. The remainder of the paper will deal with an empirical illustration of these concepts.

A illustrative cross-country comparison of full consumption

Recent work by the OECD (Ahmad and Koh 2011) has produced estimates of the value of own-account household production, using both a replacement cost and an opportunity cost method. Extended measures of household consumption were shown by the authors after adding the value of own-account household production to the value of actual final consumption (as available from the national accounts). Their conclusion, confirming other results from the literature is that there are large differences in the resulting extended measures of consumption, depending on the valuation method chosen. Valuation methods matter in particular when results are expressed as a percentage of conventional measures of consumption of GDP. Our theoretical findings above lend support to giving preference to a replacement cost valuation, as long as the purpose is measuring the value of household production.

The present empirical section will build on the authors' data and go one step further towards providing a valuation of full consumption, thus incorporating also the value of household work as a 'commodity' and leisure. We rely on the model set out earlier and distinguish between unconstrained and constrained households before aggregating across these two types of households. We then construct a spatial cost-of-living index in the form of an extended purchasing power parity to compare volume measures of full consumption across countries. It is important to stress that the resulting calculations are of an illustrative nature only. Full implementation requires separately identifying actual individual consumption of constrained and unconstrained households, an improved time use information of these two groups of households and resolving additional conceptual issues such as the distinction between a household and a person that we have conveniently ignored here. A number of additional shortcuts were necessary and consequently, the results presented here are orders of magnitude rather than precise estimates.

Valuing labour and capital services

Ahmad and Koh (2011) start with empirical information from the latest time use surveys of OECD countries as compiled by the OECD (2011). People's activities during a typical day are classified into time devoted to (i) paid work or study (work-related activities); (ii) unpaid work (household activities); (iii) personal care; (iv) leisure; and (v) other activities not included elsewhere. Allocation of time across these categories is not always straight forward, in particular in the case of

multiple activities and activities that can constitute both acts of production and leisure activities such as cooking. For the purposes of measuring household production of non-market services, the relevant activity is unpaid work, which comprises the following six sub categories: routine housework; shopping; care for household members; care for non household members; volunteer work; and travel related to household activities.

The time use data used by Ahmad and Koh (2011) makes no distinction between constrained and unconstrained households or persons. We derive a set of data that makes this distinction by separating each country's population (of persons with 16 years and above) into unemployed persons (that is, those seeking and available for employment), persons older than 65, and all other persons (that is, persons in employment and persons of working age that are not in the labour force such as persons in education). In a rather stark simplification[6], the first two groups are considered constrained, and the third group is considered unconstrained in their time allocation. We next combine the statistics on time use patterns for all households as in Ahmad and Koh (2011) with supplementary information from Krueger and Mueller (2008) on time use of unemployed and employed persons to approximate time use patterns of constrained and unconstrained persons. Again this entails a number of shortcuts and consequently, a likely source of measurement imprecision (differences in years, country coverage, classifications of activities etc.).

Valuation with replacement costs (w_N) of household labour as an input into production uses the data developed by Ahmad and Koh (2011), an average post-tax, hourly wage rate of a general household employee, deemed to be representative of the broad range of activities covered in the production of household production of non-market services.

As time spent on household production t_N and hired time q_N were considered perfect substitutes in the theoretical set-up, the valuation of hourly labour w_N under the replacement cost approach should ideally be the quality-adjusted price of a specialist worker in the activity being measured, where the quality is adjusted to reflect the productivity of non-specialised individuals. In practice however, many studies do not adjust for such quality differences, and those that do generally do so using relatively simple estimates that assume that the quality/productivity of the non-specialist is likely to be lower by a certain ratio. Landefeld *et al*. (2008), for example, assume that the average hourly wage, used as a proxy for the replacement cost, is 75% of the specialist hourly wage in a number of activities.

Measurement of the costs of labour used in the production of household non-market services for own use can simply be described as follows: value of annual labour used in household production of non-market services = average hourly post-tax labour costs of household employee * average hours worked per day * 365 (in 2008) * population 16 years and above. Where valuation of time with opportunity costs is called for (as would be the case for leisure of unconstrained households) we use Ahmad and Koh's (2011) average post-tax wage rates for the economy.

Like any other activity, both capital and labour are used in the production of household non-market services. Capital is measured as the services of consumer durables, which includes household appliances, motor vehicles and also categories of consumer durables, such as furniture, that provide

[6] For instance, all employed persons are considered non-constrained. This is clearly not true as persons may be employed and yet constrained for instance in their choice of working time. Also, discouraged workers who no more seek employment are considered unconstrained in our classification which may be subject to debate. It is also questionable whether persons outside the working age should be considered constrained in their choices as we do.

capital services related to dwelling services[7]. The usual approach, also followed by the authors, is to create estimates of the value of capital services by estimating the productive stock of consumer durables constructed using the perpetual inventory method and valuing the flow of capital services (Jorgenson and Griliches, 1967) as unit user costs[8] multiplied by the productive stock.

Tables 1 and 2 show the various components of full consumption for a selection of OECD countries. We distinguish between the value of actual individual consumption as shown in the System of National Accounts (the conceptual equivalent of p_1q_1), household production (P_NQ_N in our notation), and the value of leisure as well as the value of the 'commodity' household work.

On average, household production (and the equivalent additional consumption) with labour valued at replacement costs, adds about 50% to the value of actual final consumption although there are significant variations between countries.

The cross-country cost of living index takes the form of a new set of PPPs. The new PPPs were constructed by introducing additional 'products' into the traditional set of PPP calculations. These 'products' are the labour input to household production, capital input to household production, t_N as a 'commodity', and leisure, where a distinction is made between constrained and unconstrained persons. The monetary value for each item relative to full consumption provides the relevant weight. As would be expected, the set of adjusted PPPs turns out to be quite different from the official PPPs for actual individual consumption.

The final step consists of applying the new set of PPPs to obtain a volume comparison of per capita full consumption. Results are shown in Table 2. Given the empirical shortcuts, these should be interpreted with caution. However, it is notable that the vast majority of countries improve their position against the United States when material living standards are measured using full consumption as opposed to actual individual consumption.

Summary and conclusions

This paper has established a theoretical framework and identified conditions for the validity of the two most widely used to value household labour. The first approach towards valuing time spent on household work is the replacement cost approach that imputes a wage rate for labour services that could be purchased by the household for household work. This valuation is warranted when households are constrained in their supply of labour to the labour market. For unconstrained households, the replacement cost approach is also correct if the sole objective is valuing household production but with no 'commodity' value of time spent on household production.

Full consumption goes beyond measuring household production and includes the value of leisure and the intrinsic value of the time spent on household work. We showed that these items should be valued at opportunity costs in the case of unconstrained households and valued at replacement costs in the case of constrained households.

[7] It is important to note that the estimates of capital services produced below will be biased upwards since some consumer durables, such as cars, also provide capital services to commuting and leisure activities; and not just household non-market services.

[8] Unit user costs were measured as a real rate of return plus a rate of depreciation times the price index of new consumer durables.

Another main element of this paper has been the definition of a cost-of-living index of full consumption. We used the economic approach towards index numbers to define this price index with a view to measuring volume changes in full consumption.

Finally, we apply the findings empirically and compute comparative measures of the volume of full consumption per capita across a selection of OECD countries, thereby combining valuation and cost-of-living indexes. We conclude that moving from a comparison of actual final consumption to a comparison of full consumption has a marked influence on the relative position of countries.

Table 1 Valuation of household production, 2008

	Unpaid housework, hours per day per person			Leisure, hours per day per person			Population above 15 years of age	Value of labour spent on own account household production, at replacement costs, millions of national currency			Value of capital services after tax	Value of own-account household production, millions of national currency			Own-account household production
	All persons	Unconstrained persons[1]	Constrained persons[1]	All persons	Unconstrained persons[1]	Constrained persons[1]	1000 persons, total	All persons[2]	Unconstrained persons[1]	Constrained persons[1]	Millions of national currency	All persons[2]	Unconstrained persons[1]	Constrained persons[1]	% of Actual individual consumption
Australia	4,1	3,5	6,2	4,7	4,4	6,1	17483	532333	376620	155713	54715	587048	420906	166141	71%
Austria	3,4	2,9	5,1	4,7	4,3	5,9	7067	68128	44649	23479	15232	83359	56432	26928	47%
Belgium	3,3	2,8	5,0	5,4	5,0	6,8	8937	79302	50183	29119	15410	94713	61831	32881	41%
Canada	3,3	2,9	4,8	5,1	4,6	7,1	27718	238817	166844	71973	102054	340870	248009	92862	32%
Germany	3,5	2,9	5,2	5,6	5,1	7,0	71204	584718	344031	240687	168311	753029	465168	287861	45%
Denmark	3,6	3,2	5,3	5,5	5,2	6,6	4483	533829	366366	167463	120165	653994	460731	193263	56%
Spain	3,3	2,7	4,9	4,9	4,5	6,2	38898	390689	238870	151819	56939	447628	280929	166698	60%
Finland	3,4	2,9	4,8	5,8	5,4	6,9	4421	48208	31619	16589	8580	56788	38150	18639	46%
France	3,3	2,8	4,9	4,1	3,7	5,1	52406	549396	348266	201130	96109	645505	420996	224510	46%
United Kingdom	3,5	3,0	5,4	5,3	4,9	6,7	50488	368906	243422	125484	92433	461338	315245	146093	41%
Hungary	3,3	2,8	5,1	4,6	4,3	5,9	8537	8405457	5473020	2932436	1371325	9776782	6529313	3247469	55%
Ireland	3,5	3,1	5,6	5,3	4,9	6,8	3526	49501	35963	13538	7043	56544	41786	14758	51%
Italy	3,6	3,0	5,3	4,7	4,3	5,9	51382	466069	283432	182636	98135	564203	355660	208543	51%
Japan	2,7	2,3	4,0	3,8	3,4	4,8	110358	193979541	115429500	78550042	19679898	213659439	129612328	84047112	62%
Korea	2,3	2,0	3,6	4,9	4,6	6,4	40149	162559680	125471465	37088215	37275187	199834867	157375415	42459452	32%
Mexico	4,2	3,9	6,9	3,7	3,5	4,9	75282	2259048	1888764	370284	628361	2887409	2454010	433399	34%
Netherlands	3,6	3,2	5,7	5,3	4,9	6,8	13512	115997	80240	35758	28542	144539	103109	41431	40%
Norway	3,1	2,8	4,6	6,1	5,8	7,4	3859	430376	304330	126046	118672	549048	399440	149607	42%
New Zealand	3,8	3,3	5,8	4,1	3,8	5,3	3390	68213	48572	19641	12187	80400	58478	21923	62%
Poland	3,8	3,3	5,9	4,9	4,6	6,3	32253	240406	166962	73444	43085	283490	201572	81919	31%
Portugal	3,7	3,1	5,5	4,0	3,7	5,0	8996	74815	46378	28437	13402	88218	56370	31847	66%
Sweden	3,5	3,0	5,1	5,2	4,9	6,2	7678	787176	503909	283268	124042	911219	596738	314480	43%
United States	3,4	2,9	5,5	4,9	4,5	6,2	243169	2590250	1774902	815348	870534	3460784	2474378	986405	31%
Estonia	3,9	3,4	5,7	4,8	4,5	5,8	1110	54211	37218	16994	9340	63551	44554	18997	38%
Slovenia	3,8	3,3	6,0	5,2	4,8	6,6	1695	11445	8015	3429	2075	13519	9691	3828	57%

1 Unconstrained persons = population 16-64 years, minus unemployed persons

Constrained persons = unemployed persons plus persons of 65 years and above

Time use data by type of person are first-order approximations only and should be interpreted with great caution.

Source: estimates using data by Krueger and Mueller (2008).

2 Results for all persons are sourced from Ahmad and Koh (2011)

Source: authors' calculations.

Table 2 Valuation of household production, 2008

	Value of leisure and household work as 'commodity', millions of national currency			Full consumption, millions of national currency			Actual individual consumption (AIC) as % of full consumption	PPPs for AIC national currency per US dollar	PPPs for full consumption, national currency per US dollar	AIC per capita, USA=100	Full consumption per capita, USA=100
	All persons[2]	Unconstrained persons[1]	Constrained persons[1]	All persons	Unconstrained persons[1]	Constrained persons[1]	All persons			All persons	All persons
Australia	877512	725439	152072	2286122	1146346	318213	36%	1,4614	1,569	71,9	79,9
Austria	172047	144959	27088	434273	201391	54016	41%	0,8584	0,867	69,1	71,2
Belgium	244817	205041	39776	568837	266872	72658	40%	0,8976	0,894	66,0	70,5
Canada	1087743	982332	105411	2510567	1230340	198273	43%	1,2439	1,203	72,2	74,3
Germany	1896523	1571243	325280	4333112	2036411	613141	39%	0,8078	0,802	70,2	78,0
Denmark	1586427	1375908	210519	3412515	1836639	403782	34%	8,3938	8,657	70,3	85,2
Spain	780546	589300	191246	1973978	870229	357945	38%	0,7462	0,778	60,6	66,0
Finland	166819	142989	23830	346470	181139	42468	35%	0,9482	0,962	67,5	80,4
France	1391613	1182053	209561	3444215	1603048	434070	41%	0,8806	0,899	68,9	70,9
United Kingdom	1621522	1464127	157396	3205422	1779372	303489	35%	0,6418	0,648	78,8	95,5
Hungary	11817518	8417602	3399915	39220178	14946915	6647385	45%	126,0816	122,681	38,5	37,8
Ireland	142870	126430	16441	311301	168216	31198	36%	1,0392	1,065	67,0	78,0
Italy	966044	763302	202742	2646189	1118962	411285	42%	0,8156	0,818	63,3	64,1
Japan	378730840	283964970	94765870	936566679	413577297	178812981	37%	119,0859	129,349	62,7	67,4
Korea	1023260163	956985704	66274460	1851788931	1114361119	108733911	34%	816,3230	796,801	43,8	56,7
Mexico	5559494	5294570	264924	16949239	7748580	698322	50%	7,0863	6,574	31,1	28,7
Netherlands	435079	392072	43007	940543	495181	84437	38%	0,8336	0,828	72,9	82,0
Norway	2347841	2145686	202156	4212934	2545126	351763	31%	9,4273	9,631	81,0	108,8
New Zealand	119204	101368	17837	330125	159845	39759	40%	1,4336	1,472	58,8	62,2
Poland	709594	631352	78242	1911638	832924	160161	48%	1,7617	1,606	37,8	37,0
Portugal	98277	72420	25857	321144	128790	57705	42%	0,6792	0,691	51,6	51,9
Sweden	2720205	2371463	348743	5744618	2968201	663223	37%	8,9600	9,005	70,8	82,1
United States	11212133	10297205	914928	25692917	12771583	1901333	43%	1,0000	1,000	100,0	100,0
Estonia	153936	136528	17408	384825	181082	36405	43%	8,8065	8,160	39,2	41,7
Slovenia	16798	12994	3803	54149	22686	7631	44%	0,6387	0,633	51,0	50,2

1 Unconstrained persons = population 16-64 years, minus unemployed persons

Constrained persons = unemployed persons plus persons of 65 years and above

Time use data by type of person are first-order approximations only and should be interpreted with great caution.

Source: estimates using data by Krueger and Mueller (2008).

2 Results for all persons are sourced from Ahmad and Koh (2011)

Source: authors' calculations.

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