

## **Household Production, Leisure and Living Standards**

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### **Abstract**

Household production is an important non-market activity and the empirical literature has developed different methods towards valuing household production without, however, providing a rigorous theoretical foundation for the various approaches. We follow the literature spawned by Becker (1965) and develop a model of the household as a producer and consumer that provides a theoretical justification for the two main approaches towards valuing labour in household production, the replacement cost approach and the opportunity cost approach. 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 further 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).

### **JEL Keywords**

Valuation of household time, replacement cost valuation of time, opportunity cost valuation of time, household production, labour supply, allocation of household time.

### **Journal of Economic Literature Classification Numbers**

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## 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 the 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<sup>2</sup>.

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 input have been prevalent: valuation with a market wage rate (the ‘opportunity cost approach’) of the household member that carries out household production and valuation with a wage rate for a household employee (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 the 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 of 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).

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<sup>2</sup> 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) and 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*. Also, standard optimising models of household production à la Becker (1965) would always suggest an opportunity cost approach as the appropriate valuation, thus being at variance with the above reasoning. The first and main contribution of the present paper consists of a generalisation of Becker's (1965) full consumption model and shows how such an extended model can provide guidance to the valuation issue. We conclude that two elements condition the choice between an opportunity cost and a replacement cost approach.

- In the general case of an unconstrained household, a first element enters the considerations: is the purpose of valuing time spent on household production to capture full consumption (a welfare-related concept) 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.
- The second 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 constitute the correct valuation for own-account household services as well as for other components of full consumption, in particular leisure.

(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 major contribution of this paper is the development of a cost-of-living index for full consumption in line with our theoretical model. We show how the expenditure functions of constrained and unconstrained households can be combined to provide the theoretical basis for the derivation of an exact cost-of-living index for full consumption in the sense of Diewert (2001).

We conclude by providing some calculations of full income and household production for a cross-section of OECD countries. As the main focus and contributions of the paper are of a theoretical nature, these calculations are of an illustrative nature only. By the same token, no attempt is made here to provide a comprehensive picture of the empirical issues arising in measuring household production such as the measurement of capital input or methods of quality adjustment – the reader will be referred to the relevant literature. Some of the implementation issues will no doubt constitute the object of future research.

### **The Model**

We start by providing some intuition for our modelling. Essentially, we consider a household that faces two decisions: (i) the allocation of monetary income between various purchases, including final consumption products but also purchases of labour services for household work. (ii) the allocation of time between working in the labour market, time spent on household work or production and leisure. In the simplest of all worlds, the household is only constrained by the 24 hours of the day and the various prices and wages it faces on the market. Under these conditions, when deciding on the amount

of household production, a utility-maximising household following Becker's (1965) model of the allocation of time will compare his/her own (after tax) wage rate  $w$  with the wage rate of a household employee  $w_N$ . If  $w$  exceeds  $w_N$ , it *always* pays to hire a household employee and no own-account household work takes place. In the opposite case, it *never* pays to hire a household employee and the value of household work equals the market wage rate in this simple opportunity cost approach. But this simple set-up is not compatible with the observation that in practice there are households (probably many) whose wage rate  $w$  exceeds the wage rate of a household employee *and* they spend time on household production.

A more elaborate setting is thus needed and we introduce two extensions. The first extension<sup>3</sup> acknowledges that household work may produce utility in itself. By allowing, for instance, for the fact that parents value the time spent with children, the implicit price of child care - a household production activity - changes. Indeed, time spent on child care becomes a joint product: labour input into household production and a 'commodity' with intrinsic value. As we will demonstrate, the joint product should be valued at opportunity costs but the labour input part at replacement costs. The second extension considers the case where households are constrained in their free allocation of time. The example we use is unemployment where no time can be allocated to supplying labour to the labour market. Absent an opportunity cost on the labour market, the correct valuation of household production turns out to be the replacement cost. With both extensions we are able to define a measure of full consumption that comprises 'traditional' consumption, the consumption value of household production, the 'commodity' value of household production and the value of leisure. The following sections present these arguments in a more rigorous form.

### *Unconstrained households*

Our formal set-up starts thus with a household that is unconstrained in its allocation of consumer expenditure and in its allocation of time. In particular, there are no constraints in 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<sup>4</sup>. The own-account production process of this service is captured by the production function

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

where  $t_N$  is the amount of 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<sup>5</sup>.  $q_2$  is the quantity of intermediate inputs and/or capital services from

<sup>3</sup> This first extension is due to Pollak and Wachter (1975, p. 266).

<sup>4</sup> 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 'commodities'. The difference between  $q_1$  and  $Q_N$  is that the time input for a work type activity can be purchased on the market whereas the time spent on consuming ice cream has to be allocated by the consumer.

<sup>5</sup> This is a simplification. The empirical literature (for instance Abraham and Mackie 2005) has discussed whether one hour spent by a household member 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 rather straightforward to introduce into the theoretical

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<sup>6</sup>.

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

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

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<sup>7</sup> in  $t_N$ , and decreasing in  $t_L$ . The 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<sup>8</sup> (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).

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

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model. For instance, labour input into household production could be specified as  $\mu t_N+q_N$  where  $\mu>0$  is a quality adjustment factor for household labour.  $\mu$  would be less than unity, if household labour is less proficient than purchased labour and vice versa. It is also clear from the empirical literature that  $\mu$  is hard to measure. For the theoretical purpose at hand, and to save on notation, we stick to the simple case of  $\mu=1$ . If the quality adjustment term were carried throughout the analysis, all results for the valuation with replacement costs would carry over for the valuation with quality-adjusted replacement costs  $\mu w_N$ .

<sup>6</sup> 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.

<sup>7</sup> We shall, however, assume monotonicity so that the derivative is non-decreasing or non-increasing everywhere over the domains of interest.

<sup>8</sup> For a more general debate on Pollak and Wachter's approach towards modelling household production see Barnett (1977) and Pollak and Wachter's (1977) reply.

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 (after tax) wage rate on the labour market, so that (after tax) wage income is given by  $wt_L$ . Let  $Y$  stand for all other forms of money revenues (for instance property income) that are spent during the period under consideration.<sup>9</sup> Then the monetary budget constraint faced by the household (and pictured in the national accounts) indicates that households' disposable income equals consumption expenditure:

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

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

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<sup>9</sup> If the household's market purchases of goods and services during the period is less than its after tax labour income, then  $Y$  would be negative and would represent savings out of labour income.

$$(4) \quad w(T-t_N-t_F)+Y = p_1q_1+p_2q_2+w_Nq_N.$$

The above constraint can be rewritten as follows:

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

The left-hand side of (5) now shows a *nominal* measure of Becker's *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

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

The household's maximisation problem is then

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

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 an interior solution to the utility maximisation problem are

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

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

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

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

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

where  $f_N^*$  and  $f^*$  denote functions evaluated at the utility-maximising variables and  $\lambda^*$  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 contain information about the implicit price for time spent on household production  $t_N$  and on the optimal hiring of household labour  $q_N$ . Equation (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 a production input is  $w_N$ :

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

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:

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

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. In the more complex case where household work is an argument in the utility function, a corner solution may arise when market wages exceed wages of a household employee ( $w > w_N$ ) *and* the household derives disutility from home production ( $(\partial f / \partial t_N < 0)$ ). No time would be spent on household production and a maximum of time would be spent on



supplying labour to the labour market<sup>10</sup>. Conversely, if a household whose market wage rate is less than the wage rate of a household employee at the same time derives positive utility from household work, a corner solution arises where the household would spend a maximum of time on household production<sup>11</sup>. Although we have no evidence regarding the prevalence of corner solutions, we focus on interior solutions in what follows, assuming that they are the rule rather than the exception.

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:<sup>12</sup>

$$(15) \quad C_N(Q_N, w_N, p_2) = \min_{q_2, q_N, t_N} \{ w_N(t_N + q_N) + p_2 q_2 : f_N(t_N + q_N, q_2) \geq Q_N \}$$

$$= Q_N C_N(1, w_N, p_2)$$

$$= Q_N P_N.$$

In the first line of (15), we have made use of (11) that essentially determined 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 cost,  $C_N(1, w_N, p_2)$ , where the latter is 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

$$(16) \quad C_N(Q_N^*, w_N, p_2) = Q_N^* C_N(1, w_N, p_2) = w_N(t_N^* + q_N^*) + p_2 q_2^*.$$

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

$$(17) \quad \lambda^* p_2 q_2^* + \lambda^* w_N(t_N^* + q_N^*) = (\partial f^* / \partial Q_N) [(\partial f_N^* / \partial q_2) q_2^* + (\partial f_N^* / \partial t_N)(t_N^* + q_N^*)]$$

$$= (\partial f^* / \partial Q_N) Q_N^* \quad \text{using the linear homogeneity of } f_N.$$

Next, combine (17) and (16) in order to obtain the following equations:

$$(18) \quad \lambda^* [p_2 q_2^* + w_N(t_N^* + q_N^*)] = \lambda^* Q_N^* C_N(1, w_N, p_2)$$

$$= \lambda^* Q_N^* P_N = (\partial f^* / \partial Q_N) Q_N^* \quad \text{and} \quad \lambda^* P_N = (\partial f^* / \partial Q_N).$$

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  $\lambda^*$ ) equals the marginal utility that households derive from own-account services  $Q_N^*$ .

<sup>10</sup> There are natural limits to supplying labour (minimum leisure, sleeping) that have not been modelled here. Institutional and legal limits such as maximum hours for full-time employment would bring us to the case of constrained households dealt with below.

<sup>11</sup> The household's budget and time constraints imposes a limit to the time spent on household production, as the household needs a minimum market income to purchase  $q_1$ -type products in line with condition (8). At this point, the only remaining trade-off is between household work and leisure. Such a situation may be relevant for low-income households with potentially important distributional implications.

<sup>12</sup> See Diewert (1993) for additional material and references to the literature on duality theory.

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.

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

Under the regularity conditions imposed on  $f$  and household behavior, 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

$$(20) \quad \begin{aligned} e(u^*, p_1, P_N, w, w_N) &= p_1 q_1^* + P_N^* Q_N^* + (w - w_N) t_N^* + w t_F^* \\ &= p_1 q_1^* + p_2 q_2^* + w_N q_N^* + w t_N^* + w t_F^* \quad \text{by using (18)} \\ &= FC = FI. \end{aligned}$$

Note that  $t_N^*$  is valued at its shadow price, so in considering full consumption and substituting  $P_N^* Q_N^*$  for  $p_2 q_2^* + w_N q_N^* + w_N t_N^*$ , we end up with  $w t_N^*$  as the value of time spent on household work. We can now draw some conclusions concerning the case of an unconstrained household that supplies market labour services:

- 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 constrained in their labour supply*

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 and study the consequences for the valuation of household time.<sup>13</sup> One situation that characterises a constrained household is unemployment – a person seeking employment at a given wage rate without success. Similarly, a person with involuntary part-time work is faced with a constraint to supply additional labour. In principle, a constraint on labour supply can also arise when there are legal limits to the maximum hours of work per week. Fully-employed persons who wish to extend their labour supply would then not be able to do so<sup>14</sup>. Similarly, persons who have reached retirement age and wish to keep supplying labour to the labour market may be constrained in their choice if retirement age is compulsory. While these and similar cases are covered by our model, it is apparent that identifying the existence of these

<sup>13</sup> Note that the approach that we followed in the previous section, which essentially follows that of Becker (1965), cannot be used when the household has no opportunity to supply market labour services.

<sup>14</sup> If one follows this reasoning, a necessary condition to be unconstrained in the choice of labour supply is to be in a situation of part-time work (or exactly at the optimising path with a full-time employment).

constraints household-by-household is difficult in practice. Our empirical illustration below will therefore be confined to the most apparent case of constrained labour supply, unemployment.

For purposes of the theoretical exposition, 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

$$(21) \quad t_F + t_N = T.$$

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

$$(22) \quad Y = p_1 q_1 + p_2 q_2 + w_N q_N.$$

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

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

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

$$(24) \quad \max_{q_1, q_2, q_N, t_F} \{F(q_1, Q_N, t_F) : p_1 q_1 + p_2 q_2 + w_N q_N \leq Y; Q_N = f_N(t_N + q_N, q_2)\}.$$

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  $p_1 q_1^* + p_2 q_2^* + w_N q_N^* = Y$ . When  $F$  is differentiable, the first order necessary conditions are:

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

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

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

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

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:

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

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

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

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:

$$\begin{aligned}
(31) \quad & \lambda^* [p_2 q_2^* + w_N q_N^* + w_N t_N^*] \\
& = [\partial F^* / \partial Q_N] [(q_N^* + t_N^*) (\partial f_N^* / \partial q_N) + q_2^* (\partial f_N^* / \partial q_2)] \\
& = [\partial F^* / \partial Q_N] f_N^* \quad \text{using the linear homogeneity of } f_N \\
& = [\partial F^* / \partial Q_N] Q_N^* = \lambda^* P_N^* Q_N^* \quad \text{using (1) and (18).}
\end{aligned}$$

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:

$$\begin{aligned}
(32) \quad & E(u^*, p_1, P_N, w_N) \\
& = p_1 q_1^* + P_N Q_N^* + w_N t_F^* \\
& = p_1 q_1^* + p_2 q_2^* + w_N q_N^* + w_N t_N^* + w_N t_F^* \quad \text{using (15),}
\end{aligned}$$

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 equations:

$$\begin{aligned}
(33) \quad & p_1 q_1^* + P_N Q_N^* + w_N t_F^* = Y + w_N t_N^* + w_N t_F^* \\
& \quad \quad \quad = Y + w_N T \quad \text{using the time constraint (21)}
\end{aligned}$$

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.<sup>15</sup>

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*  $Q_N$ . This valuation for valuing household work is the same as our suggested valuation for 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.

<sup>15</sup> This concept for Full Income could be labelled as *Restricted Full Income* in order to distinguish it from Becker's Full Income.

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.

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

$$\mathbf{P}_a \equiv [p_1, P_{N,a}, w_N, w]; \quad \mathbf{P}_p \equiv [p_1, P_{N,p}, w_N];$$

$$\mathbf{Q}_a \equiv [q_{1,a}, Q_{N,a}, t_{N,a}, t_{F,a}]; \quad \mathbf{Q}_p \equiv [q_{1,p}, Q_{N,p}, t_{N,p}, t_{F,p}];$$

$$\mathbf{p}_a \equiv [p_1, p_2, w_N, w]; \quad \mathbf{p}_p \equiv [p_1, p_2, w_N, w_N];$$

$$\mathbf{q}_a \equiv [q_{1,a}, q_{2,a}, q_{N,a}, t_{N,a}, t_{F,a}]; \quad \mathbf{q}_p \equiv [q_{1,p}, q_{2,p}, q_{N,p}, t_{N,p}, t_{F,p}].$$

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  $\varepsilon$  by weighting each expenditure function by the number of households:

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

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

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

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

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  $\mathbf{u}$ . 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:

$$(37) \quad P^*(\mathbf{u}^0, \mathbf{P}_a^0, \mathbf{P}_p^0, \mathbf{P}_a^1, \mathbf{P}_p^1)$$

$$\leq \sum_{j=a,p} n_j P_j^1 \cdot Q_j^0 / \sum_{j=a,p} n_j P_j^0 \cdot Q_j^0$$

$$= \sum_{j=a,p} n_j P_j^1 \cdot q_j^0 / \sum_{j=a,p} n_j P_j^0 \cdot q_j^0 \equiv P_L^* \quad \text{using (20);}$$

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

$$\geq \sum_{j=a,p} n_j P_j^1 \cdot Q_j^1 / \sum_{j=a,p} n_j P_j^0 \cdot Q_j^1$$

$$= \sum_{j=a,p} n_j P_j^1 \cdot q_j^1 / \sum_{j=a,p} n_j P_j^0 \cdot q_j^1 \equiv P_L^* \quad \text{using (32);}$$

$$(39) \quad P_F = (P_L^* P_P^*)^{1/2}.$$

$P_F^*$  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:

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

where  $FC^0 = \sum_{j=a,p} n_j p_j^0 \cdot q_j^0$  and  $FC^1 = \sum_{j=a,p} n_j p_j^1 \cdot q_j^1$ .

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. To keep things manageable empirically, only unemployment is used as a criterion for identifying a constrained household. 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. Also, as we heavily rely on the data provided by Ahmad and Koh (2011) for our calculations, no attempt is made here to replicate the discussion of the various measurement issues that these authors provide, such as the statistical sources for the various wage rates and time use surveys. Consequently, the following section only presents the most salient features of the data work involved.

### ***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<sup>16</sup>, 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 capital services related to dwelling services<sup>17</sup>. The usual approach, also followed by the authors, is to

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<sup>16</sup> 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.

<sup>17</sup> 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.

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<sup>18</sup> multiplied by the productive stock.

To get a sense for the orders of magnitude involved, Table 1 presents results for the nominal value of household production that do not discriminate between types of households – average time use patterns are applied. Two valuations of labour input are presented, at replacement costs and at opportunity costs. It is apparent (see last column) that results vary critically with the choice of valuation methods. Similarly, any ratio of household production over GDP or over actual individual consumption would vary strongly, depending on the method. However, as our theoretical considerations have shown, in an extended model of households, if the measurement purpose is valuation of household production only (rather than full consumption) the replacement cost method is the correct way to proceed. As the same replacement cost wage rate is applied to constrained and unconstrained households, our results for the value of household production are identical to Ahmad and Koh's (2012) computations at replacement costs.

But full consumption goes beyond the value of household production and includes the value of household production, both directly and as a 'commodity', the value of direct consumption  $p_1q_1$  as well as the value of leisure. We use Actual Individual Consumption as shown in the System of National Accounts to capture  $p_1q_1$ , the value of household production  $P_NQ_N$  is measured at replacement costs and the value of household production as a commodity plus leisure are valued at opportunity costs or replacement costs, depending on the type of household. Table 2 presents the results. It starts by discriminating between constrained and unconstrained households in their time use regarding household production and leisure. This is unnecessary for the computation of the nominal value of household production but matters for the valuation of leisure as well as for the construction of price indices. The final columns in Table 2 present the nominal values of household production and of full consumption as a percentage of actual individual consumption. 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. Full consumption – a welfare-related measure - is considerably higher. On average, full consumption is more than 2.5 times the value of actual individual consumption. It is of note that the spread of these ratios declines as one moves from comparing the relative size of household production to the relative size of full consumption.

An important step involves moving from nominal to real considerations. To compare real full consumption across countries, the cost of living index derived in the theoretical part of this paper 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 3. 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. We are also in a position to compare our results for real

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<sup>18</sup> Unit user costs were measured as a real rate of return plus a rate of depreciation times the price index of new consumer durables.



full consumption with those shown by Ahmad and Koh (2012). The authors do not account for leisure and the intrinsic value of household production. The last column in Table 3 shows the difference in volume indices. It is apparent that moving from actual individual consumption plus household production to full consumption tends to improve the position of high-income countries such as Norway, Denmark and Australia whereas it tends to worsen the position of lower-income countries such as Mexico, Poland or Estonia. This is consistent with the idea that the volume and value of leisure tends to rise with rising income.

### *Summary and conclusions*

This paper has established a theoretical framework and identified conditions for the validity of the two most widely used approaches 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.

Our theoretical model also demonstrates that full consumption goes beyond measuring household production and should include the value of leisure and the intrinsic value of the time spent on household work. We show 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.

Another main element of this paper is the definition of a cost-of-living index of full consumption. We use 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.

Many research and measurement issues remain, for instance the treatment of joint production within households, measuring productivity change in household production, differentiating between types of expenditures such as educational investments and consumption. Another policy-relevant question is whether moving towards full consumption and full income affects distributional measures such as the Gini coefficient or the difference between average and median income.

Table 1 Household production valued at replacement costs and at opportunity costs, 2008

	Value of own-account household production	Population above 15 years of age	Value of labour spent on own-account household production		Value of capital services after tax	Value of own-account household production		
	Hours per day per person	1000 persons, total	At replacement costs, millions of national currency	At opportunity costs, millions of national currency	Millions of national currency	At replacement costs, millions of national currency	At opportunity costs, millions of national currency	Replacement costs in % of opportunity costs
Australia	4,1	17483	532333	698303	54715	587048	753018	78%
Austria	3,4	7067	68128	115441	15232	83359	130673	64%
Belgium	3,3	8937	79302	144912	15410	94713	160323	59%
Canada	3,3	27718	238817	636099	102054	340870	738153	46%
Germany	3,5	71204	584718	1177610	168311	753029	1345921	56%
Denmark	3,6	4483	533829	962602	120165	653994	1082767	60%
Spain	3,3	38898	390689	512213	56939	447628	569152	79%
Finland	3,4	4421	48208	92730	8580	56788	101311	56%
France	3,3	52406	549396	1022856	96109	645505	1118964	58%
United Kingdom	3,5	50488	368906	981179	92433	461338	1073612	43%
Hungary	3,3	8537	8405457	8487291	1371325	9776782	9858616	99%
Ireland	3,5	3526	49501	86458	7043	56544	93500	60%
Italy	3,6	51382	466069	702785	98135	564203	800920	70%
Japan	2,7	110358	193979541	266309877	19679898	213659439	285989774	75%
Korea	2,3	40149	162559680	431270701	37275187	199834867	468545888	43%
Mexico	4,2	75282	2259048	4518096	628361	2887409	5146457	56%
Netherlands	3,6	13512	115997	265669	28542	144539	294211	49%
Norway	3,1	3859	430376	1121691	118672	549048	1240363	44%
New Zealand	3,8	3390	68213	98196	12187	80400	110383	73%
Poland	3,8	32253	240406	480812	43085	283490	523896	54%
Portugal	3,7	8986	74815	87626	13402	88218	101028	87%
Sweden	3,5	7678	787176	1725291	124042	911219	1849334	49%
United States	3,4	243169	2590250	6925596	870534	3460784	7796130	44%
Estonia	3,9	1110	54211	108423	9340	63551	117763	54%
Slovenia	3,8	1695	11445	12255	2075	13519	14330	94%

Source: Ahmad and Koh (2012).

Table 2 Household production with differentiated households, 2008

Country/Unit	Own-account household production			Value of labour spent on own account household production, at replacement costs	Value of capital services after tax	Value of own-account household production at replacement costs	Leisure			Value of leisure and household work as 'commodity'			Actual individual consumption (AIC)	Full consumption	Own-account household production	Full consumption				
	All persons	Unconstrained persons <sup>1</sup>	Constrained persons <sup>1</sup>				All persons	Unconstrained persons <sup>1,2</sup>	Constrained persons <sup>1,3</sup>	All persons	Unconstrained persons <sup>1,2</sup>	Constrained persons <sup>1,3</sup>					All persons	All persons	Share of Actual individual consumption	Share of Actual individual consumption
Australia	4.1	3.5	6.2	532333	54715	587048	4.7	4.4	6.1	877512	725439	152072	821563	2286122	71%	278%				
Austria	3.4	2.9	5.1	68128	15232	83359	4.7	4.3	5.9	172047	144959	27088	178867	434273	47%	243%				
Belgium	3.3	2.8	5.0	78302	15410	94713	5.4	5.0	6.8	244817	205041	39776	229307	568837	41%	248%				
Canada	3.3	2.9	4.8	238817	102054	340870	5.1	4.6	7.1	1087743	982332	105411	1081953	2510587	32%	232%				
Germany	3.5	2.9	5.2	584718	168311	753029	5.6	5.1	7.0	1895523	1571243	325280	1683560	4333112	45%	257%				
Denmark	3.6	3.2	5.3	533829	120165	653994	5.5	5.2	6.6	1586427	1375908	210519	1172094	3412515	56%	291%				
Spain	3.3	2.7	4.9	390689	56939	447628	4.9	4.5	6.2	780546	589300	191246	745804	1973978	60%	265%				
Finland	3.4	2.9	4.8	48208	8580	56788	5.8	5.4	6.9	168819	142989	23830	122863	346470	46%	282%				
France	3.3	2.8	4.9	549396	96109	645505	4.1	3.7	5.1	1391613	1182053	209561	1407097	3444215	46%	245%				
United Kingdom	3.5	3.0	5.4	368906	92433	461338	5.3	4.9	6.7	1621522	1464127	157396	1122561	3205422	41%	286%				
Hungary	3.3	2.8	5.1	8405457	1371325	9776782	4.6	4.3	5.9	11817518	8417602	3399915	17625878	39220178	55%	223%				
Ireland	3.5	3.1	5.6	49501	7043	56544	5.3	4.9	6.8	142870	126430	16441	111887	311301	51%	278%				
Italy	3.6	3.0	5.3	466069	98135	564203	4.7	4.3	5.9	966044	763302	202742	1115941	2646189	51%	237%				
Japan	2.7	2.3	4.0	193979541	19679898	213659439	3.8	3.4	4.8	378730840	283664970	94765870	344176400	936566679	62%	272%				
Korea	2.3	2.0	3.6	162559680	37275187	199834867	4.9	4.6	6.4	1023260163	956965704	66274460	628693900	1851788931	32%	295%				
Mexico	4.2	3.9	6.9	2259048	628361	2887409	3.7	3.5	4.9	5559494	5294570	264924	8502337	16949239	34%	199%				
Netherlands	3.6	3.2	5.7	115997	28542	144539	5.3	4.9	6.8	435079	392072	43007	360925	940543	40%	261%				
Norway	3.1	2.8	4.6	430376	118672	549048	6.1	5.8	7.4	2347841	2145686	202156	1316045	4212934	42%	320%				
New Zealand	3.8	3.3	5.8	68213	12187	80400	4.1	3.8	5.3	119204	101368	17837	130520	330125	62%	253%				
Poland	3.8	3.3	5.9	240406	43085	283490	4.9	4.6	6.3	709594	631352	78242	918554	1911638	31%	208%				
Portugal	3.7	3.1	5.5	74815	13402	88218	4.0	3.7	5.0	98277	72420	25857	134650	321144	66%	239%				
Sweden	3.5	3.0	5.1	787176	124042	911219	5.2	4.9	6.2	2720205	2371463	348743	2113194	5744618	43%	272%				
United States	3.4	2.9	5.5	2590250	870534	3460784	4.9	4.5	6.2	11212133	10297205	914928	11020000	25692917	31%	233%				
Estonia	3.9	3.4	5.7	54211	9340	63551	4.8	4.5	5.8	153936	136528	17408	167338	384825	38%	230%				
Slovenia	3.8	3.3	6.0	11445	2075	13519	5.2	4.8	6.6	16798	12994	3803	23832	54149	57%	227%				

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 Valued at opportunity costs

3 Valued at replacement costs

Source: authors' calculations.

Table 3 Full consumption in real terms, 2008

Reference group	Value of own-account household production			Value of leisure and household work as 'commodity'		Actual individual consumption (AIC) as share of full consumption	PPPs for AIC consumption	PPPs for full consumption	AIC per capita relative to the USA	Full consumption per capita relative to the USA	Own-account production at replacement costs plus AIC, volumes as in Ahmad and Koh (2012)	Difference
	All persons <sup>2</sup>	Unconstrained persons <sup>1</sup>	Constrained persons <sup>1</sup>	All persons <sup>2</sup>	Unconstrained persons <sup>1</sup>							
Country/Unit	Millions of national currency			Millions of national currency		All persons	All persons	National currency per US dollar	USA = 100	USA = 100	USA = 100	Percentage points
Australia	587048	420806	166141	877512	725439	152072	821563	1,4614	71.9	79.9	67.8	12.1
Austria	83359	56432	26928	172047	144959	27088	178967	0,8584	68.1	71.2	74.1	-2.9
Belgium	94713	61831	32881	244817	205041	39776	229307	0,8876	66.0	70.5	73.4	-3.0
Canada	340870	248009	92862	1087743	982332	105411	1081953	1,2439	72.2	74.3	84.6	-10.3
Germany	753029	465168	287861	1898523	1571243	325280	1683560	0,8078	70.2	78.0	79.6	-1.6
Denmark	653994	460731	193263	1586427	1375908	210519	1172094	8,3938	70.3	85.2	71.8	13.4
Spain	447628	280829	166898	780546	589300	191246	745804	0,7462	60.6	66.0	62.7	3.3
Finland	58788	38150	18639	166819	142969	23830	122863	0,9482	67.5	80.4	71.6	8.8
France	645505	420996	224510	1391813	1182053	209861	1407097	0,8806	68.9	70.9	71.0	-0.1
United Kingdom	461338	315245	146093	1621522	1464127	157398	1407097	0,6418	78.6	95.5	82.8	12.7
Hungary	9776782	6528313	3247469	11817518	8417602	3399915	1172581	126,0818	38.5	37.8	56.2	-17.4
Ireland	56544	41786	14758	142870	126430	16441	111887	1,0392	67.0	78.0	69.1	8.9
Italy	564203	355660	208543	966044	763302	202742	1115941	0,8156	63.3	64.1	72.3	-8.2
Japan	213659439	129612328	84047112	378730840	283964970	94765870	344176400	119,0859	62.7	67.4	55.9	11.5
Korea	199834867	157375415	42459452	1023260163	956985704	66274460	628693900	816,3230	43.8	56.7	52.7	4.0
Mexico	2887409	2454010	433399	5559494	5294570	264924	8502337	796,801	43.8	28.7	61.0	-32.3
Netherlands	144539	103109	41431	435079	392072	43007	360925	0,8336	72.9	82.0	81.6	0.3
Norway	549048	399440	149607	2347841	2145688	202156	1316045	9,4273	81.0	108.8	78.7	30.1
New Zealand	80400	58478	21923	119204	101368	17837	130520	1,4336	58.8	62.2	64.3	-2.2
Poland	283490	201572	81919	709594	631352	78242	1811638	1,7617	37.8	37.0	68.7	-31.7
Portugal	88218	56370	31847	98277	72420	25857	134650	0,6792	51.6	51.9	62.0	-10.1
Sweden	912119	596738	314480	2720205	2371463	348743	2113184	6,9600	70.8	82.1	76.7	5.4
United States	3460784	2474378	986405	11212133	10297205	914928	11020000	1,0000	100.0	100.0	100.0	0.0
Estonia	63551	44554	18997	153936	136528	17408	167338	8,8065	39.2	41.7	66.3	-24.5
Slovenia	13519	9691	3828	16798	12994	3803	23832	0,6387	51.0	50.2	65.8	-15.6

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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