VALUING THE SERVICES OF CONSUMER DURABLES

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Although consumer durables are treated as nondurables in most economic accounts, economists have long recognized that they could be treated as capital. If an estimate of the value of the services of consumer durables was available, it could be included in personal consumption expenditures and purchases of the durables treated as a form of investment. Such treatment would give a better picture of changes in a nation's economic welfare over time and make international comparisons more meaningful.

This article reviews the economic literature on how the services of consumer durables can be valued. It examines six alternative measures: the (1) user cost; (2) capital recovery; (3) opportunity cost; (4) market rental value; (5) cost of a substitute; and (6) cash-equivalent value measures. The first three are based on the summation of the costs of the inputs used to produce the services, although only the first two are consistent with the principle that the purchase price of a durable equals the discounted present value of its expected future benefits. The fourth and fifth measures are based on the prices of marketed services while the sixth is derived from the consumer's demand function for the good's services. The article also discusses six major issues in implementing these measures: (1) imputing a rate of return to capital; (2) measuring declines in market value (depreciation and capital gains); (3) accounting for operating expenditures; (4) adjusting for capacity utilization; (5) deflating service values; and (6) defining consumer durables.

This article reviews the economic literature on how the services of consumer durables can be valued. It examines alternative measures, their theoretical underpinnings, and major issues and problems in their implementation.

In most economic accounts, consumer durables are treated as nondurables, i.e., only current expenditures on purchases of them are accounted for. Yet, economists have long recognized that they could be treated as capital, yielding valuable services and an income to their owners in each year of their lives. Early support for this viewpoint is found in the writings of Alfred Marshall and Irving Fisher. Marshall cited Adam Smith as defining a person's capital as "that part of his stock from which he expects to derive an income," and went on to claim that a "broad" use of the term income

> ... embraces the whole of benefits of every sort which a person derives from the ownership of property however applied: it includes for instance the benefits which he gets from the use of his own piano, equally with those which a piano dealer would win by letting a piano for hire. [36, p. 77]

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Irving Fisher [12, p. 52] adopted a very broad definition of capital, namely "a stock of wealth existing at an instant of time," and advocated that, at least in theory, nondurables such as food should be treated as capital, if they were not consumed instantaneously after being purchased [12, p. 106]. In his framework consumers expect that the value of the services of any of their capital goods will exceed outlays on the good, i.e., they expect to derive a net income from purchasing durables.

This article deals with the measurement of this net income and service stream. Estimates of their value would make it possible to treat consumer and producer durables in a similar manner in national economic accounts. On the product side of the accounts, the services of consumer durables would be included in personal consumption expenditures, and purchases of the durables would become a form of investment. Changes consistent with these—the addition of measures of the returns to capital, indirect business taxes, and depreciation—would be made on the income side of the accounts.[1]

There are several reasons why treating consumer durables as capital in a system of national accounts may give a better picture of changes in a nation's economic welfare over time and make international comparisons more meaningful. First, expenditures on consumer durables generally fluctuate widely over the course of a business cycle while the value of their services moves more smoothly. Second, the inclusion of the net return on consumer durables in measures of net national product and national income substantially raises their magnitudes and makes comparisons of them over time more meaningful if, for example, there are large shifts in consumers' relative holdings of consumer durables and liquid assets. Third, some durables such as cars and washing machines can be owned either by consumers or by businesses that rent the durables (or their services) to consumers. Changes in the percentage of such durables owned by consumers may have a significant impact on national economic accounts unless they are treated as capital regardless of who owns them. Analogously, comparisons between countries that differ in the percentage of durables owned by consumers will suffer if the durables are treated as capital when businesses own them and as nondurables when consumers own them.

This article is organized into two sections. The first consists of a discussion of general measures of "service value." These include measures based on the prices of marketed services, and a measure based on the owner's demand for the service. The second section discusses major issues in valuing the services of consumer durables, most of which are related to the implementation of the opportunity and user cost measures.

[1]In a household production framework, the services of consumer durables would be the capital input to a household production function whose output would include the benefits from using consumer durables, such as the number of loads of laundry washed. The time that households spend using the durables would be the corresponding labor input. Questions related to changes in the productivity of many consumer durables can be analyzed in such a framework. To conduct such analyses, however, data is required on household time use, the value of that time, and the value of the output generated by using consumer durables.

I. Measures of Service Value

This section discusses alternative measures of service value.[2] The measures are classified into three groups: (1) measures based on input costs, consisting of user cost, capital recovery, and opportunity cost measures; (2) measures based on the price of marketed services, consisting of market rental value and cost of a substitute service measures; and (3) a measure of the service's value to the consumer—cash-equivalent value.

A. *Measures Based on Input Costs*

In the economic literature, estimates of the services of consumer durables have generally been based on the summation of the costs of the inputs used to produce the services. These costs invariably include depreciation and an imputed net return to capital, and in some cases include other costs such as expenditures on repairs, maintenance, taxes, insurance (on a car), and interest paid on borrowings to finance the durable's purchase. The imputed net return is an "opportunity cost." If a consumer is rational, the net return he expects to receive from owning a durable must be at least equal to the net return that he expects to receive on the best foregone investment.

1. Measures Based on the Principle of Present Discounted Value

a. User Cost

The user cost measure provides an estimate of the market rental price based on costs of owners. It is directly derived from the principle that the purchase price of a durable good equals the discounted present value of its expected future benefits.[3] To see this, let $P_{s,t}$ denote the purchase price of an s year old durable at the beginning of year t; $P^e_{s+1,t+1}$ denote its expected purchase price at the beginning of year $t+1$ when the durable is one year older; $C^e_{s,t}$ denote the expected service value of this s year old durable in year t; and r^e_t denote the expected rate of interest (or rate of return on alternative investments) in year t. Expected variables are measured as of the beginning of year t. Assume that the entire value of the durable's services in any year will be received at the end of the year, and that the durable is expected to have a service life of m years. From the definition of discounted present value,

$$(1) \qquad P_{s,t}=\frac{C^e_{s,t}}{1+r^e_t}+\frac{C^e_{s+1,t+1}}{(1+r^e_t)(1+r^e_{t+1})}+\ldots+\frac{C^e_{m-1,t+m-s-1}}{\prod_{i=t}^{t+m-s-1}(1+r^e_i)}$$

[2]In the terminology adhered to throughout this paper, "service value" denotes the value of a durable's services. John W. Kendrick termed this a gross rental value and others have often referred to it as an implicit rental value. The term "net return to capital"—sometimes called net rent or imputed interest by others—as used here denotes the service value less all expenses incurred in obtaining the durable's services (that have not already been netted out) except for interest paid on loans to finance the purchase of the durable, i.e., net return consists of the return on both the debt and equity portions of the durable's value.

[3]This is a condition for consumer equilibrium that results from the process of intertemporal utility maximization.

and similarly,

$$P^e_{s+1,t+1} = \frac{C^e_{s+1,t+1}}{(1+r^e_{t+1})} + \frac{C^e_{s+2,t+2}}{(1+r^e_{t+1})(1+r^e_{t+2})} + \frac{C^e_{m-1,t+m-s-1}}{\prod_{i=t+1}^{t+m-s-1}(1+r^e_i)}. \tag{2}$$

Dividing both sides of (2) by $(1+r^e_t)$ and subtracting the result from (1) yields

$$P_{s,t} - \frac{P^e_{s+1,t+1}}{1+r^e_t} = \frac{C^e_{s,t}}{1+r^e_t} \tag{3}$$

Multiplying both sides of (3) by $(1+r^e_t)$ and combining terms one obtains the user cost measure

$$C^e_{s,t} = r^e_t P_{s,t} + (P_{s,t} - P^e_{s+1,t+1}). \tag{4}$$

Equation (4) states that in equilibrium the annual service value that a consumer expects to receive from owning a durable equals the costs that the consumer expects to bear from not selling it at the beginning of the year, i.e., foregone interest, plus the expected decline in the market value of the durable during the year. The expected decline in market value may be partitioned into depreciation and expected capital losses. The depreciation component measures the decline in the market value of the durable due to its aging. The capital loss (gain) component represents the change in the price of the durable due solely to changes in price levels (i.e., deflation or inflation); expected capital gains reduce service value. Under various conditions including perfect competition, no transactions costs, and no differential taxation on different types of income, the service value from (4) will equal the market rental price for the durable.[4] The user cost measure has been derived by such theorists as Harold Hotelling [20], Dale W. Jorgenson [25], R. E. Hall [17], and Kenneth J. Arrow [2]. It can be estimated from data on prices of used durables by making an assumption about the relationship between expected and actual prices. This has been done quite often in studies relating to automobiles, probably because the required data on prices of used automobiles is readily available. Examples of this include works by Wolfhard Ramm [42 and 43], Frank C. Wykoff [48 and 49], Terry R. Johnson [24], and Susan Rose Ackerman [1].

Arnold J. Katz [30] has shown that the traditional user cost measure given in (4) should be modified to make it more consistent with the principles used in national economic accounting. Specifically, he argues that to be more consistent with these principles one should assume that equal quantities of a durable's services are received in every fraction of the year. When this is done, the annual service value is approximately equal to the value in (4) divided by the square root of one plus the nominal rate of return, which is the service value obtained by assuming that all services are received on the mid-day of the year.

When data on the prices of used durables is not available, the user cost measure can be estimated by making an assumption about the ratio of the prices

[4]The condition ruling out transactions costs should be interpreted as ruling out the case where consumers buy "at retail" and sell "at wholesale."

of new and used durables.[5] Assuming that the ratio of the price of an s year old durable to that of a new one is always equal to $(1-\delta_s)^s$, where δ_s is a constant, and assuming perfect foresight (i.e., $P^e_{s+1,t+1}=P_{s+1,t+1}$) yields

$$P^e_{s+1,t+1}=(1-\delta_s)P_{s,t+1}.$$

Substituting these results into equation (4) yields

$$C^e_{s,t}=r^e_tP_{s,t}+P_{s,t}-(1-\delta_s)P_{s,t+1}$$

or, rearranging terms

$$C^e_{s,t}=r^e_tP_{s,t}+\delta_sP_{s,t+1}+(P_{s,t}-P_{s,t+1}). \tag{5}$$

The value assumed for δ_s largely determines the measured service values. This type of user cost measure has been used by Laurits R. Christensen and Dale W. Jorgenson [3 and 4], Barbara M. Fraumeni and Dale W. Jorgenson [13], and Katz [30] to calculate service values of consumer durables that could be included in an adjusted GNP. It has also been utilized to measure the service value of producer durables in numerous econometric studies concerned with productivity measurement, investment behavior, and the demand for capital.

b. Capital Recovery

The capital recovery measure is a measure of service value that satisfies two conditions: (1) the durable's annual service value in current dollars is the same in every year of its life, and (2) the present discounted value of the service values received over the life of the durable equals its original purchase price. Mathematically, the service value is determined by the following equation

$$C_{s,t+s}=P_{0,t}\left(\frac{r}{(1+r)^m-1}+r\right)\qquad s=0,1,\ldots,m-1 \tag{6}$$

where $C_{s,t+s}$ is the estimated service value of an s year old durable in year $t+s$; $P_{0,t}$ is the price of a new (0 year old) durable in year t; r is the appropriate rate of return; and m is the durable's service life in years.[6]

The above measure has associated with it the use of a constant rate of return over the durable's entire life. As this feature need not be used in the other measures examined in this article, it will be considered to be part of the capital recovery approach. This feature seems to force the analyst to choose between two alternatives: (1) assuming that investment in a given class of durables is forever associated with a single rate of return, or (2) using different rates of return to value the services of durables that are identical except for their ages.

Using equation (6) is tantamount to utilizing depreciation measured in historical costs. At a given point in time, durables that only differ with respect to age are measured in prices of different periods. Moreover, in a period of

[5]Equivalently, one could make assumptions about the relative efficiency of used durables (the ratio of their service value to that of a new durable), future rates of inflation in durable prices, and future discount rates.

[6]The expression in parenthesis is called a capital recovery factor. Its present discounted value equals one.

deflation, the measure in equation (6) will value the services of old durables more highly than those of new durables of the same type.

In opportunity and user cost measures it is often assumed that a durable's service value in *constant* dollars is the same in every year of its life. However, it is not clear why one would want to hold a durable's service value in *current* dollars constant over its life. The capital recovery measure has primarily been used as a decision-making tool in capital planning (Eugene L. Grant and W. Grant Ireson [14]). In at least one case, it has been used to calculate service values for producer durables (Michael Hanemann [18]).

2. Opportunity Cost

The opportunity cost measure equals the sum of depreciation and an imputed net return.[7] Often other (operating) costs are added to this. The net return is measured by taking the actual rate of return on some alternative investment and multiplying it by the value of the net stock.[8] Although many investigators have proposed using it as a measure of service value, the opportunity cost measure does not appear to result from any formally derived model.

Replacement-cost depreciation and nominal rates of return have usually been used in empirical estimation of the opportunity cost measure, although Arnold J. Katz and Janice Peskin [31] have published some estimates using historical-cost depreciation and purchase-year rates of return. Estimates of depreciation that are used in opportunity cost measures are not a function of the rate of return. However, estimates of depreciation that are internally consistent with the user cost measure are, in general, a function of the rate of return.

The opportunity cost measure primarily differs from the user cost measure in that capital loss is not added to the other costs of owning the durable. Equivalently, one may state that the opportunity cost measure embodies the assumption that consumers expect that the rate of inflation in the durable's price will be zero during the coming year. If a real rather than a nominal rate of return is used, capital loss is implicitly included in the net return and the opportunity cost measure will closely approximate the user cost measure.

The opportunity cost measure also differs from those previously mentioned in that the other measures are formally derived from the discounted present value principle, and can be interpreted as *ex ante* measures, i.e., measures of service values that consumers expect to receive. The opportunity cost measure cannot be so interpreted. It has been used as if it were an *ex post* measure, but a theoretical rationale for this use is lacking.

The opportunity cost measure has been used by Simon Kuznets [35], Solomon Fabricant [11], F. Thomas Juster [27], John W. Kendrick [33], Robert Eisner [8], Ismail Abdel-Hamid Sirageldin [45], and Katz and Peskin [31] to value the services of consumer durables. Willford I. King [34], Nicholas Kaldor [29], and Nancy and Richard Ruggles [44] have also proposed using it for this purpose.

[7]Finding a suitable term for the opportunity cost measure is difficult as all of the measures based on input costs include a net return based on the opportunity cost concept.

[8]Some authors have used different rates of return on the equity and debt portions of the stock.

B. *Measures Based on the Prices of Marketed Services*

The measures examined in this section represent attempts to value non-market services by the current value of similar services that are marketed. Net returns derived from them may be viewed as estimates of an *ex post* return.

1. Market Rental Value

The value of a durable's services can be taken to be equal to the market rental value of an analogous good when appropriate data exists. Juster [27] and Ruggles and Ruggles [44] have suggested that this type of measure could be used to value the services of consumer durables. This measure is already used by the Bureau of Economic Analysis (BEA) to value the services of owner-occupied housing. Basically, BEA measures the gross rent (space rent) of owner-occupied housing from data on the rent paid for similar housing with the same market value.[9] To get the service value that is added to GNP (gross housing product) the value of intermediate goods and services included in this figure (e.g., expenditures for repair and maintenance, insurance, condominium fees, and closing costs) are subtracted from the space rent. To obtain a net return (net rental income), depreciation, taxes, and net interest are subtracted from, and subsidies added to, the service value. Thus, the net return is calculated rather than assumed as in the cost-based approaches.

The amount that a consumer could obtain by renting out a durable (less the difference between the out-of-pocket expenses—including taxes and transactions costs—incurred in renting and not renting out the durable) may be interpreted as the opportunity cost of not renting out the durable. Consequently, if a durable is not rented out, the owner must value its services at least at this amount. Market rental values may be a poor measure of the value of a durable's services to its owner when the difference between the out-of-pocket expenses of owners that rent out durables and those that do not is relatively large. Also, many durables are only rented on a short-term basis while values for longer rental periods seem more appropriate.

Market rents may differ from the costs of owner-users because: (1) owners that rent out durables may incur certain expenses not incurred by owner-users, including taxes on net rental income, advertising and other selling costs, etc.; and (2) there may be systematic differences between owners that rent out durables and owner-users for the same categories of expenses, e.g., insurance, maintenance and repair, etc. The latter differences can arise because market rents reflect the rate of utilization of rented durables at the margin while the costs of owner-users reflect their rates of utilization. Thus, the annual market rent for a car will reflect the fact that rented cars are driven on the average X miles a year. The costs of

[9] Although new homes are often purchased with certain household appliances included, BEA does not treat such consumer-owned appliances as capital in the National Income and Product Accounts. The value of these durables is reflected in personal consumption expenditures (PCE), just as if they were purchased separately from the houses. Consequently, the imputed (gross) rental value of owner occupied housing consists only of space rent and excludes the rent of appliances. However, the rental value of tenant-occupied housing that appears in PCE includes the rental value of appliances owned by landlords.

an owner-user who drives his car only $X/3$ miles a year would be considerably different.

2. Cost of a Substitute Service

Several writers have discussed valuing the services of an owned durable and its net return in terms of the cost of a substitute for that service. Where market rental values exist for the durable, they would presumably be used, but in their absence substitute services would be valued, e.g., laundromat costs would be used to value the services of a home-owned washer and dryer. F. K. Wright stated that the services of an asset already owned by a firm could be measured by their "opportunity value," which

> ... is measured by the least costly of the alternatives avoided through owning the services.
>
> The problem of valuing the services of an asset thus reduces to the problem of determining the alternatives to ownership of that asset, assessing the costs or losses associated with those alternatives, and selecting the least of those costs or losses to represent the value of the services [47, p. 278].

J. V. Poapst and W. R. Waters [41] used the costs of laundromats, and movies and sporting events to value the services and net return of automatic washers and dryers, and television sets. F. Thomas Juster and Robert P. Shay [28, pp. 16–17] and Juster [27, p. 7 and p. 120] have also suggested that the net return on consumer durables could be measured by the difference between the cost of substitute services and the cost (except for the net return) of the durables.

A major theoretical difficulty in using the cost of a substitute service is that using the least costly of substitute services as a measure of value implies that higher levels of service rendered by other substitutes are of no value. While there is some rationale for this rule in valuing the services of producer durables, the case for applying it to consumer durables is much weaker. The usefulness of the cost of a substitute service measure seems to rest on the ability to identify an extremely close substitute for the durable in question. Suppose that one wanted to value the services of a diamond necklace and that data on the market rental values of only emerald and rhinestone necklaces were available. Should one use the rental value of the rhinestone necklace as the measure of value since it is the least costly substitute, or should one declare that "equivalent" services are only provided by the emerald necklace?

C. *Cash-Equivalent Value*

A good's "cash-equivalent value" is the minimum cash compensation that would be required for the consumer to voluntarily sell his rights to it.[10] In other words, it represents the amount that the consumer would have to be compensated for the loss of these rights in order to keep him at the same level of utility that

[10]This section draws heavily on the results of a comprehensive examination of this measure by Gershon Cooper and Arnold J. Katz [5].

he enjoyed before losing them. It is based on Hick's equivalent variation (see J. R. Hicks [19, p. 34] and Michael P. Murray [40, p. 774]), and is a welfare-oriented measure derived from the consumer's demand function for the good. It differs from other measures of service value in that it yields values that are different for: (1) individuals with different demand (or utility) functions, and (2) individuals with identical demand functions but different money incomes. The cash-equivalent value is related to the other measures in that if the market rental value of a durable exceeds the costs incurred in owning it, the cash-equivalent value of the durable's services will lie somewhere between these two extremes. Furthermore, if a consumer can rent out an owned durable, the value that he places on its services can be no less than the durable's market rental value less the difference between the out-of-pocket expenses incurred in renting and not renting out the durable. Thus, the cash-equivalent value is of particular interest when the difference in these expenses is large.

The cash-equivalent measure has been used extensively to compare incomes in situations where prices are different, as in the computation of cost of living indexes. It has also been used to value in-kind income, i.e., Medicaid, Food Stamps, public housing benefits, price subsidies, and other goods received by individuals for less than their market price. It has not yet been used to value the services of durables, probably because the calculation of exact measures would require estimation of demand curves for these services. While the difficulties of obtaining such estimates may prevent implementation of the measure, it is still useful to consider how it relates to the other measures of service value.

D. *A Numerical Illustration*

The following illustrates the ways in which the preceding measures of service value can be implemented. Suppose that a car was produced and sold in 1981, that during 1982 its owner drove it during 100 days, and that had he not owned the car, he would have rented a comparable one for 70 days. What was the car's service value in 1982, assuming certain parameters?

Estimates of service value based on the alternative measures discussed earlier are shown in Table 1. They are based on the assumed parameters shown

TABLE 1

ILLUSTRATIVE ESTIMATES OF THE SERVICE VALUE IN 1982 OF A CAR THAT WAS PRODUCED IN 1981

(IN CURRENT DOLLARS)

Estimate No.	Measure of Service Value	Service Value
1	User cost, variant A	2337
2	User cost, variant B	1780
3	Capital recovery	1614
4	Opportunity cost, variant A	2155
5	Opportunity cost, variant B	3053
6	Market rental value	3400
7	Cost of a substitute, variant A	2300
8	Cost of a substitute, variant B	1610

TABLE 2
PARAMETERS FOR THE COMPUTATION OF THE SERVICE VALUE OF A CAR PRODUCED IN 1981

	Date of measurement		
	1/1/81 (A)	1/1/82 (B)	1/1/83 (C)
(I) Market value of a new car (in current dollars)	8,000	8,200	8,700
(II) Average market value of a car produced in 1981 (in current dollars)	—	7,400	6,100
(III) Average market value of a car produced in 1980 (in current dollars)	6,900	5,800	4,800
(IV) Rental charge for the next 12 months on a car produced in 1981 (in current dollars)	—	3,400	2,800
(V) Daily rental charge for a car produced in 1981 (in current dollars)	21.00	22.00	24.00
(VI) Price index for new cars	100.00	102.50	108.75
(VII) Balance due on car loan (in currrent dollars)	—	5,847	4,818
(VIII) Interest paid on car loan during the previous 12 months (in current dollars)	—	447	1,130
(IX) Interest rate on loans for all cars (in percent per annum)	15.5	16.5	18
(X) Interest rate on loans for new cars (in percent per annum)	14.5	15.5	17
(XI) Rate of return on financial assets (in percent per annum)	6	6.5	7
(XII) Rate of return on residential property, including capital gains (in percent per annum)	8.5	9	10
(XIII) Length of life of a new car (in years)	10	10	10

in Table 2, and are reflective of the estimating methods used by others. Estimate #1 is a user cost measure calculated from market prices for used durables. Estimate #2 is a user cost measure based on the prices of newly-produced durables and double-declining-balance depreciation. Estimate #3 is a capital recovery measure. Estimate #4 is an opportunity cost measure with a net stock calculated by the perpetual inventory method and straight-line depreciation; in calculating the net return, a single interest rate is applied to both the debt and equity portions of the net stock. Estimate #5 is identical to this except that 2.5-declining-balance depreciation is used, and different interest rates are applied to the equity and debt portions of the net stock. Estimate #6 is the market rental value. Estimates #7 and #8 use the cost of a substitute for the durable's services, with the former estimate reflecting the actual usage of the owned durable, and the latter reflecting the usage that would have been made of the substitute for it. The computational details for each specific measure are shown in the appendix.

These estimates vary widely. In part this reflects the assumptions in Table 2; in reality, such wide differences may not exist. Nevertheless, this exercise does illustrate some significant points. First, measures of service value that have different conceptual bases may yield similar estimates, e.g., the user cost and cost of a substitute measures are quite close in value. Second, estimates based on the same measure of service value may differ widely, depending on specific assumptions. For example, variant B of the opportunity cost measure, which uses declining balance depreciation, is 42 percent larger than variant A, which uses straight-line depreciation, although to some extent this difference washes out over the life of the durable. Because of the importance of these assumptions, it is necessary to address the question of how service values should be measured in more detail. This is done in the next section, which focuses on major issues in implementing the general measures of service value.

II. Major Issues in Valuing the Services of Consumer Durables

Each of the measures discussed in the previous section could be implemented in a variety of ways, each yielding different estimates of service value. In this section these variants are discussed in terms of a series of distinct issues: (1) imputing a rate of return to capital; (2) measuring declines in market value (depreciation and capital gains); (3) accounting for operating expenditures; (4) adjusting for capacity utilization; (5) deflating service values; and (6) defining consumer durables. Most of these issues arise from the implementation of the opportunity and user cost measures because these measures are discussed most often in the literature.

A. *Imputing A Rate of Return to Capital*

In order to implement the opportunity and user cost measures of service value it is necessary to select an appropriate rate of return to capital.[11] An examination of Table 3 reveals the wide divergence in the rates used by various investigators. This divergence stems from differences relating to such issues as the riskiness of the investment, the treatment of taxes, and the use of a single rate on all durables regardless of type, method of financing, or date of purchase.

In a Fisherian equilibrium model, there is a single economy-wide interest rate. Such a rate has been used in user cost measures. However, given the observed variation in market rates of return on investments, what single rate should be used? Also, when multiple rates of return are permitted, a variety of other issues emerge. These are discussed in turn.

1. The Single Rate of Return

If the same rate of return is used for all durables, so that the total value of the net stock of consumer durables is multiplied by a single rate of return, what rate should be used? There are numerous alternatives: a rate on financial

[11]Most of the issues discussed here are also relevant to selecting the appropriate discount rate in the capital recovery method. In addition to the issues mentioned here, there is disagreement about whether the net return should be calculated by applying the appropriate rate to the beginning or end-of-year net stock, or some function of the two. Christensen and Jorgenson [3 and 4] used the value of the net stock at the beginning of the income period, Ramm [42 and 43] used an end-of-period net stock, and Kendrick [33] and Eisner [8] apparently used an average value of the net stock during the period.

TABLE 3

RATES OF RETURN USED IN EMPIRICAL STUDIES

Author	Rate Applied to the Debt Portion of the Net Stock	Rate Applied to the Equity Portion of the Net Stock
Christensen and Jorgenson [3 and 4], and Fraumeni and Jorgenson [13]	After tax rate of return on residential property including capital gains	Same as on debt portion
Eisner [8]	Borrowing rate, initial estimates taken from Juster	Same as on debt portion
Eisner, Simons, Pieper, and Bender [10]	Borrowing rate on new autos is applied to the stock of autos, borrowing rate from James Smith is applied to the remainder	Same as on debt portion
Fabricant [11]	An assumed constant rate	Same as on debt portion
Juster [27]	Not applicable	Rate jointly determined by the cost of consumer instalment credit and the relative importance of credit purchases to total purchases
Katz [30], and Katz and Peskin [31]	Borrowing rate on new autos is applied to debt due to new car loans, the average rate on other borrowings is applied to the remainder	Average yield on financial assets is applied to the portion owned by consumers who had no debt, average rate on other borrowings is applied to the remainder
Kendrick [33]	Borrowing rate (on all outstanding loans that financed purchases of consumer durables)	Rate on savings (weighted yield on personal holdings of time deposits, U.S. government securities, and common stocks)
Kuznets [35]	Yield on prime grade bonds	Same as on debt portion
Ramm [42 and 43][a]	Borrowing rate on newly-made loans (for autos)	Same as on debt portion
Sirageldin [46][a]	Rate on savings; lower rates on a family's second and third cars	Same as on debt portion
Wykoff [49][a]	Adjusted rate on prime commercial paper, 4–6 months to maturity	Same as on debt portion

[a]The studies by Ramm, Sirageldin, and Wykoff valued only the services of automobiles.

borrowings, on savings, and a weighted average of the two; a rate on nonfinancial investments, e.g., residential housing, perhaps adjusted for capital gains; and the consumer's subjective rate of time preference. Furthermore, there is some controversy about whether it should be the maximum observed rate, the average observed rate, or the rate of return earned on investments that have the same degree of risk and liquidity as the durables whose services are being valued.

2. DIFFERING RATES BY TYPE OF FINANCING

Durables may be purchased with borrowed funds or with owned funds. In some studies the same rate is applied to both the debt and equity portions of the value of the net stock. Kendrick [33], however, valued the debt portion using a borrowing rate (what the consumer actually paid in interest) and the equity portion using a rate on savings (what the consumer could have earned on alternative financial investments). The rationale for this is that if a consumer financed the purchase of a durable entirely by borrowing, then the value placed on its services must have been no less than what was paid to acquire it. If the durable, however, was purchased without borrowing, the expected rate of return must have been no less than that on alternative investments.

Katz and Peskin [31] used a savings rate to value the portion of the net stock owned by consumers without any personal debt, and borrowing rates to value the remainder. Their rationale for this is that for owners of durables with some personal debt, a reduction in that debt generally yields a higher return than investment in financial assets. For these consumers the borrowing rates represent the highest foregone rates. For owners of durables with no personal debt, the opportunity foregone is investment in financial assets. In the Katz–Peskin approach, it is not necessary to compute the value of the debt portion of the net stock of consumer durables. In the approaches taken by both Kendrick and Katz and Peskin, the service value of identical durables can differ depending on whether their owners borrowed to purchase them.

3. Differing Rates by Type of Durable

Should the same rate be used for all types of consumer durables? In one set of estimates, Juster [27] assumed that the rate of return to equity on major consumer durables (automobiles, furniture, household appliances, and musical instruments) was different from that on minor ones (tableware, books, toys, etc.). A rationale for this exists in the earlier work of Juster and Shay [28], who found that borrowing rates for transactions involving certain types of durables were different from those on transactions involving other types of durables. In instances where loans are tied to the purchase of specific durables, the argument seems convincing. However, loans are not always strictly tied to specific assets, so that a mortgage on a house may finance purchases of other durables, such as furniture.

4. Differing Rates by Purchase Year

In virtually all implementations of the user cost measure, current-year rates of return have been utilized for the entire stock of durables, regardless of purchase date. This seems appropriate when there are well-developed rental or resale markets for durables. When such markets do not exist, there is a case for using purchase-year rates of return. The argument for this methodology is that it uses the rates of return faced by owners when they chose to purchase the durables; no other choice with respect to those durables is open to their owners in subsequent years. This methodology causes the net return in the current year to be determined by a mixture of past and current rates, and causes durables that are identical except for their ages to have different rates of return.

5. Before- or After-Tax Rates

Should the rate of return be a before- or after-tax rate? Returns on most financial assets are subject to tax and in the U.S., the interest paid on funds borrowed may be deducted to derive taxable income (for taxpayers who itemize their deductions); yet returns to consumer durables are not subject to tax. As the before-tax return on durables need have been no higher than the after-tax return on alternatives foregone to have justified their purchase, after-tax rates on the alternatives should be used to estimate the service value of owners that use their own durables.[12] This implies that when the net return to the debt portion of the stock is estimated by the amount of interest that was actually paid, it should be reduced by the amount of tax savings resulting from the deductability of this interest from taxable income. To compute the amount that businesses would charge to rent out a durable, however, before-tax rates should be used.

B. *Measuring Declines in Market Value (Depreciation and Capital Gains)*

The expected decline in the market value of a durable during the income period is usually defined to be equal to depreciation plus expected capital losses (minus expected capital gains).[13] Why should depreciation and expected gains on consumer durables be separately estimated? When the opportunity cost measure is used, the answer is obvious since capital losses are not included in the estimated service value. When the user cost measure is utilized, the answer is not so obvious as the decline in a durable's market value could be estimated without estimating depreciation or expected capital gains.

There are three main reasons for separately estimating depreciation and expected capital gains. First, if the service value of consumer durables were to be added to GNP on the product side of the accounts, it would be necessary to estimate depreciation to measure NNP, national income, and other aggregates on the income side of the accounts. Second, when secondhand prices of durables are not available, declines in market value are usually estimated by summing separate estimates of depreciation and capital losses. Third, some economists believe that capital gains should be added to GNP or an individual's income. For instance, Eisner [9], Ramm [42 and 43], and Michael McElroy [37, 38, and 39] have advocated including in GNP "real capital gains" or "net revaluations," i.e., increases in value in excess of those due to general price inflation, while Robert Murray Haig [16] and Henry C. Simons [45] have advocated including money capital gains, i.e., all increases in value, in measures of an individual's taxable income.

[12]The use of after-tax rates can create further conceptual problems as consumers are faced with different marginal tax rates due to the progressivity of the personal income tax. Consequently, even when there is a single economy-wide before-tax rate, after-tax rates will differ between individuals causing the service value of identical durables to differ.

[13]The definitions of depreciation that are utilized in user cost and opportunity cost measures differ somewhat. For example, in their user cost framework, Hulten and Wykoff [21] define "economic depreciation" on an s year old durable as the change in its price due to aging and measure it by $P_{s,t}-P_{s+1,t}$. This measure utilizes beginning-of-year prices. In conventional replacement cost depreciation, depreciation on an s year old durable in year t is measured by $\bar{P}_{s,t}-\bar{P}_{s+1,t}$, where $\bar{P}_{s,t}$ denotes the average price of an s year old durable in year t, which is approximately equal to $(P_{s,t}+P_{s,t+1})/2$.

Estimates of depreciation that are used in opportunity cost measures of service value are generally calculated by assuming that the ratio of the price of an s year old durable to a new one is given by a particular mathematical function that depends on the durable's estimated service life and is independent of time, i.e., the ratio of the price of an s year durable to a new one is the same in every year. The prices of used durables that are used to calculate depreciation when the user cost measure of service value is utilized should be consistent with the present discounted value equation, equation (1), which is used to derive the measure of service value. In general, these prices will be a function of the nominal rate of return and the expected rate of inflation in the price of the durable. Here prices are usually determined by assuming that a durable's relative efficiency of capital is determined by a mathematical function that depends on the durable's age and estimated service life, but is independent of time.

What method of depreciation should be used? In conventional straight-line depreciation, the ratio of the price of an s year old durable to the price of a new one declines linearly from one to zero as s increases, and constant-dollar depreciation on a durable is the same in every year of its life. This method is used by the Bureau of Economic Analysis and is advocated by Eisner [8, p. 46] and Edward F. Denison [7, p. 106]. In declining-balance depreciation, constant-dollar depreciation on a durable is equal to a fixed percentage of the durable's constant-dollar price at the beginning of the year, and the durable's constant-dollar price declines geometrically as the durable ages. Jorgenson and his associates [3, 4, and 13] have used double-declining-balance depreciation to estimate stocks and service values for consumer durables, while Kendrick [33] used 2.5-declining-balance depreciation for automobiles, and double-declining-balance depreciation for other consumer durables.[14] Double-declining-balance depreciation produces net stocks, and, hence, net returns that are considerably smaller than those estimated using the straight-line method. The straight-line method generally produces estimates of aggregate depreciation that are slightly smaller than those estimated using double-declining balance depreciation.

In user cost estimates, what assumption should be made about expected inflation? The majority of studies have used an assumption of "perfect foresight," i.e., consumers are assumed to foresee prices at the end of the year so that the expected decline in the market value of a durable equals the actual decline. This assumption causes estimated service values to be *less* than their actual values by the amount of unexpected capital gains.

If other assumptions about consumers' expectations are made, there will usually be a divergence between expected and actual declines in market value (or expected and actual capital gains). Several such types of assumptions have been mentioned in connection with user cost measures. In some of their estimates, Johnson [24] and Katz [30] assumed that expected prices are a geometrically weighted average of past prices. A special case of this, static expectations, was used by Ramm [42 and 43] in one of his sets of estimates of automobile service values. Here, the price expected at the end of the year equals the actual price

[14]Actually, Jorgenson assumed geometric declines in the relative efficiency of capital, which, given his other assumptions, is equivalent to using conventional geometric depreciation.

at the beginning of the year so that expected capital gains are equal to zero.[15] Johnson found empirical support for the ssumption that consumers' expectations are static with respect to real prices.

C. *Accounting for Operating Expenditures*

In the cost-based measures, service values can be calculated by adding operating costs (e.g., expenditures on maintenance and repair, gasoline, and property insurance) to other costs (i.e., the net return and depreciation) so that an increase in operating costs causes service values and an augmented GNP that includes service values both to rise.[16] There is, however, a question of whether this treatment is correct.[17]

In Hotelling's formulation of the user cost model [20], a durable's expected service value less expected operating expenditures (plus the expected scrap value), all discounted to the present, equals its purchase price. This suggests that any operating expenditure that is expected in advance, e.g., an expenditure for the replacement of a car's brakes, must be added to other cost components to obtain the expected service value.[18] However, suppose that there is an unexpected expenditure that enables the durable to reach its expected service life; e.g., a car's axle unexpectedly breaks and an expenditure is made to repair it. Here it might be appropriate to exclude the unforeseen expenditure from the summation of the durable's other costs, causing the calculated service value to equal the expected service value. (The breaking of the car's axle did not cause its service value to increase.) This treatment is not appropriate for all unexpected expenditures. As Zvi Griliches [15, p. 203] has pointed out, expenditures on maintenance and repair may be a substitute for purchases of newer durables. A consumer may extend the life of a durable beyond the length originally anticipated by making certain maintenance and repair expenditures that were not contemplated when the durable was purchased (e.g., the engine of an old car can be overhauled). Even though such expenditures are unexpected they should be added to other costs of the durable. In conclusion, it may be impossible to determine in practice whether a given operating expenditure ought to be summed with a durable's other costs. Even if it were clear that they should be counted, there is a further question of whether maintenance and repair expenditures ought to be capitalized or treated as a current cost.[19]

[15]Katz [30] found that when this assumption and one that service values are independent of age are made, the user cost measure differs negligibly from an opportunity cost measure estimated using conventional straight-line depreciation.

[16]Kendrick [33] used this procedure in his opportunity cost measure.

[17]This issue does not occur in implementing the market rental value measure, which uses an *ex post* net return. Here, an unexpected increase in operating costs would leave service values and an augmented GNP unchanged, and net returns lower by the amount of the increase, unless rents were increased to cover the higher costs.

[18]The price of a durable depends on the discounted present value of the net benefits (service value less operating costs) expected to be derived from owning it. An increase in expected operating costs for the current period reduces the durable's price at the beginning of the period. Thus, if expected operating expenditures for the current period increase from $0 to $M, then *ceteris paribus*, the service value calculated from equation (4) will fall by $M and $M must be added to it to obtain the correct service value.

[19]In a different context George Jaszi [22, pp. 82–83] indicated that it might be appropriate to capitalize at least part of car repair and maintenance expenditures.

D. *Adjusting for Capacity Utilization*

Estimates of capital input have been adjusted for variations in capacity utilization (i.e., the percent of productive capacity that has been utilized) in making estimates of productivity (Jorgenson and Griliches [26]). Others have criticized these adjustments (Denison [6 and 7] and Kendrick [32]). Should similar adjustments be made in estimating the service value of consumer durables?

The issue can best be understood with reference to an example. Suppose that in year 1 the average owned automobile is driven 12,000 miles during 122 days and that during year 2 it is driven 15,000 miles during 130 days. Should estimates of automobile service values for these two years reflect these differences? Should they take into account the time during which the car was driven and/or the mileage it was driven?

The case for making adjustments for capacity utilization would be strong if they did not alter the total service value yielded by a durable over its lifetime. Such adjustments would then merely increase the service value in the periods that a durable was used intensively and decrease it in others. However, adjustments for capacity utilization do affect estimates of lifetime service values. Furthermore, if two individuals owned identical automobiles for 10 years, but the first drove his car more miles and used it on more days than the second, an adjustment for capacity utilization would imply that the services received by the first owner were more valuable than those received by the second. This implication would be hard to defend if both owners received precisely the quantity of services they expected to when they purchased the cars. Also, a consumer may desire to purchase excess capacity, say, by purchasing a washing machine that can wash more clothes per load but costs more than smaller machines. A downward adjustment in the service value of this machine to reflect that it is used less often than smaller ones would imply that the excess capacity was of no value, which is refuted by the consumer's observed behavior.

E. *Deflating Service Values*

How should the current-dollar service value of the stock of consumer durables be deflated to value these services in "real" terms? Kuznets [35] calculated a constant-dollar net return by multiplying a constant-dollar net stock by a current nominal interest rate. Kendrick [33] estimated real service values by deflating each of the components of the current-dollar measure separately. He calculated a real net return by multiplying the value of the net stock in constant dollars by the nominal rate of return in the base year, and added it to constant-dollar values of depreciation and other components of service value. Katz and Peskin [31] calculated constant-dollar service values by extrapolating service values in the base year by constant-dollar gross stocks.

Alternatively, one could define real service values to be directly proportionate to the quantity of capital. Then if the quantity of capital and the age distribution of the stock were to remain constant while all prices doubled and interest rates increased by the rate of inflation, current-dollar service values would more than double using the opportunity cost approach, they would exactly double using the user cost approach, and constant-dollar service values would be unchanged in both approaches. Kendrick's procedure yields a real service value that is approximately proportionate to the quantity of capital. Similarly, one could define real service values to be directly proportionate to a measure of the quantity of services yielded by the stock, an approach taken by Katz [30]. The Katz–Peskin procedure can be interepreted as utilizing this approach by regarding the constant-dollar gross stock as a crude measure of the quantity of services.[20]

F. *Defining Consumer Durables*

The final issue is how to define consumer durables or what tangible goods owned by consumers ought to be treated as capital. The Bureau of Economic Analysis defines consumer durables as those durables that have an average life of at least 3 years.[21] In recent years, the vast majority of economists have accepted the idea that these goods ought to be treated as capital. Some have advocated a more inclusive definition. Eisner [8] and Eisner *et al.* [10] imputed interest on and depreciated the stock of household semidurables (clothing, footwear, and semidurable house furnishings) and Juster [27, p. 10] has advocated treating all goods yielding services in more than one period as capital. Kendrick [33], however, treated household semidurables as inventories, imputing interest on the stock but not depreciating it. This treatment of semidurables as inventories is apparently based on the assumption that for goods with short lives, depreciation is roughly equal to expenditures. Similarly, the decision to treat some goods with extremely short lives (e.g., food) as nondurables is apparently based on the practical consideration that the difference between their service value and expenditures on them is very small.

Appendix: Calculation of Estimates for Table 1

Estimate #1, User Cost Measure (Variant A), which utilizes prices for used durables, the borrowing rate on cars (as the rate of return), and an assumption of perfect foresight (about future car prices)

(1) Net return to capital component of current-dollar service value during 1982 = (II C) × (X C) = \$1,037
(2) Decline in the current-dollar value of the car during 1982 = (II B) − (II C) = \$1,300
(3) Current-dollar service value during 1982 = (1) + (2) = \$2,337

Estimate #2, User Cost Measure (Variant B), which utilizes double-declining-balance depreciation, the rate of return on residential property (as the rate of return), and an assumption of perfect foresight (about future car prices)

[20]Note that the space rent of owner-occupied housing is deflated by prices derived from the CPI, a methodology that is different from those noted above.

[21]This classification is only an approximation as it is applied to broad categories (e.g., all clothing is considered nondurable although fur coats generally last for more than 3 years).

(1) Current-dollar value of a new car on 7/1/81 = ((I A) + (I B)) ÷ 2 = \$8,100
(2) Price index for new cars on 7/1/81 = ((VI A) + (VI B)) ÷ 2 = 101.25
(3) Constant-dollar value of the car on 7/1/81[a] = ((1) ÷ (2)) × (VI A) = \$8,000
(4) Constant-dollar value of the car on 1/1/82 = (3) − ((3) × 0.5 × 2 ÷ (XIII A)) = \$7,200
(5) Constant-dollar value of the car on 1/1/83 = (4) − ((4) × 1.0 × 2 ÷ (XIII A)) = \$5,760
(6) Current-dollar value of the car on 1/1/82 = (4) × (VI B) ÷ (VI A) = \$7,380
(7) Current-dollar value of the car on 1/1/83 = (5) × (VI C) ÷ (VI A) = \$6,264
(8) Decline in current-dollar value of the car during 1982 = (6) − (7) = \$1,116
(9) Net return to capital component of current-dollar service value during 1982 = (6) × (XII B) = \$664.20
(10) Current-dollar service value during 1982 = (8) + (9) = \$1,780.20

Estimate #3, Capital Recovery Measure, which utilizes the borrowing rate on cars (as the rate of return)

(1) Rate of return during 1982 = ((X A) + (X B)) ÷ 2 = 0.15
(2) Service life = ((XIII A) + (XIII B)) ÷ 2 = 10
(3) Capital recovery factor given (1) and (2) = 0.19925
(4) Price of acquiring the car on 7/1/81 = ((I A) + (I B)) ÷ 2 = \$8,100
(5) Current-dollar service value during 1982 = (3) × (4) = \$1,613.93

Estimate #4, Opportunity Cost Measure (Variant A), which utilizes the borrowing rate on cars (as the rate of return) and straight-line depreciation

(1) Current-dollar value of a new car on 7/1/81 = ((I A) + (I B)) ÷ 2 = \$8,100
(2) Price index for new cars on 7/1/81 = ((VI A) + (VI B)) ÷ 2 = 101.25
(3) Constant-dollar value of the car on 7/1/81 = ((1) ÷ (2)) × (VI A) = \$8,000
(4) Constant-dollar value of the car on 1/1/82 = (3) − ((3) × 0.5 ÷ (XIII A)) = \$7,600
(5) Constant-dollar value of the car on 1/1/83 = (4) − ((3) × 1.0 ÷ (XIII A)) = \$6,800
(6) Current-dollar value of the car on 1/1/82 = (4) × (VI B) ÷ (VI A) = \$7,790
(7) Current-dollar value of the car on 1/1/83 = (5) × (VI C) ÷ (VI A) = \$7,395
(8) Average current-dollar value of the car during 1982 = ((6) + (7)) ÷ 2 = \$7,592.50
(9) Average interest rate on car loans during 1982 = ((IX B) + (IX C)) ÷ 2 = 0.1725

[a]Constant-dollar values are measured in this appendix using prices of 1/1/81.

(10) Net return to capital component of current-dollar service value during 1982 = (8) × (9) = \$1,309.71
(11) Constant-dollar value of depreciation during 1982 = (4) − (5) = \$800
(12) Price index for new cars on 7/1/82 = ((VI B) + (VI C)) ÷ 2 = 105.625
(13) Depreciation component of current-dollar service value during 1982 = (11) × (12) ÷ (VI A) = \$845
(14) Current-dollar service value during 1982 = (10) + (13) = \$2,154.71

Estimate #5, Opportunity Cost Measure (Variant B), which utilizes the rate of return on financial assets as the rate of return on equity, interest paid on borrowings for the remainder of the net return, and 2.5-declining-balance depreciation

(1) Current-dollar value of a new car on 7/1/81 = ((I A) + (I B)) ÷ 2 = \$8,100
(2) Price index for new cars on 7/1/81 = ((VI A) + (VI B)) ÷ 2 = 101.25
(3) Constant-dollar value of the car on 7/1/81 = ((1) ÷ (2)) × (VI A) = \$8,000
(4) Constant-dollar value of the car on 1/1/82 = (3) − ((3) × 0.5 × 2.5 ÷ (XIII A)) = \$7,000
(5) Constant-dollar value of the car on 1/1/83 = (4) − ((4) × 1.0 × 2.5 ÷ (XIII A)) = \$5,250
(6) Current-dollar value of the car on 1/1/82 = (4) × (VI B) ÷ (VI A) = \$7,175
(7) Current-dollar value of the car on 1/1/83 = (5) × (VI C) ÷ (VI A) = \$5,709.38
(8) Average current-dollar value of the car during 1982 = ((6) + (7)) ÷ 2 = \$6,442.19
(9) Average debt portion of current-dollar value of the car during 1982 = ((VII B) + (VII C)) ÷ 2 = \$5,332.50
(10) Average equity portion of current-dollar value of the car during 1982 = (8) − (9) = \$1,109.69
(11) Average rate of return on equity during 1982 = ((XI B) + (XI C)) ÷ 2 = 0.0675
(12) Current-dollar net return on equity during 1982 = (10) × (11) = \$74.90
(13) Net return to capital component of current-dollar service value during 1982 = (12) + (VIII C) = \$1,204.90
(14) Constant-dollar value of depreciation during 1982 = (4) − (5) = \$1,750
(15) Price index for new cars on 7/1/82 = ((VI B) + (VI C)) ÷ 2 = 105.625
(16) Depreciation component of current-dollar service value during 1982 = (14) × (15) ÷ (VI A) = \$1,848.44
(17) Current-dollar service value during 1982 = (13) + (16) = \$3,053.34

Estimate #6, Market Rental Value Measure

(1) Current-dollar service value during 1982 equals the market rental value of an analogous good = (IV B) = \$3,400

Estimate #7, Cost of a Substitute Measure (Variant A), which utilizes costs for the period the owned durable was used

(1) Average daily rental value during 1982 in current dollars = ((V B) + (V C)) ÷ 2 = \$23.00
(2) Current-dollar cost of renting a car for actual period used in 1982 = (1) × 100 days = \$2,300
(3) Current-dollar service value during 1982 = lower of (IV B) and (2) = \$2,300

Estimate #8, Cost of a Substitute Measure (Variant B), which utilizes costs for the period a rented durable would have been used

(1) Average daily rental value during 1982 in current dollars = ((V B) + (V C)) ÷ 2 = \$23.00
(2) Current-dollar cost of renting a car for period it would have been used in 1982 if actually rented = (1) × 70 days = \$1,610
(3) Current-dollar service value during 1982 = lower of (IV B) and (2) = \$1,610

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