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DOUBLE-COUNTING OF INVESTMENT

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ABSTRACT

The national-income accounts double-count investment, which enters once when it occurs and again in present value as rental income on added capital. The double-counting implies overstatement of levels of GDP and national income. Across countries, those with higher propensities to invest artificially look richer gauged by per capita GDP. There is also exaggeration of capital-income shares. An alternative measure involves a form of full expensing of gross investment. In the steady state, revised product and income correspond to consumption. Outside of the steady state, the measure deviates from consumption because full expensing applies to the long-run flow of gross investment.

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In setting up a system of national accounts, Kuznets (1941) stressed that the only true final goods are consumption at various dates. Therefore, a reasonable test for a national accounting system for production and income is how well it measures the potential for consumption over time. As Kuznets put it (p. 46): "Is it the value of goods *produced* that leads to the most valid appraisal of the positive contents of economic activity? Since the final aim is to satisfy the wants of ultimate consumers, we might perhaps more properly center attention on ultimate consumption."

If the only final goods are consumption in various periods, a reasonable requirement for a measure of national product or income is that it accurately reflect, subject to data constraints, the resources available for consumption. More specifically, a necessary condition from an intertemporal perspective is that—at least conceptually—the present value of production and income should equal the present value of consumption. However, the usual measures of national or domestic product and income fail this test because they double-count investment. Gross or net product includes gross or net investment when it occurs and includes the corresponding present value a second time when additional rental income results from the enhanced stocks of capital. From the standpoint of the intertemporal budget constraint for consumption, aggregates such as GDP and national income overstate the resources available for consumption and also exaggerate capital's share of product and income.

In a model with a representative agent, such as the one constructed in the next section, welfare corresponds to the single agent's attained utility. Then, with no labor-leisure choice, welfare depends only on the time path of consumption. More generally, measured welfare would factor in the path of leisure time and the distributions of consumption and leisure, as suggested by a report written for the U.S. Senate by Kuznets (1934, pp. 6-7):

> "Economic welfare cannot be adequately measured unless the personal distribution of income is known. And no income measurement undertakes to estimate the reverse side of income, that is, the intensity and unpleasantness of effort going into the earning of income. The welfare of a nation can, therefore, scarcely be inferred from a measurement of national income … "

The present paper deals with how the reported aggregates of product and income relate to the path of aggregate consumption. Therefore, the analysis relates to welfare in so far as welfare depends on the path of aggregate consumption, rather than, *per se*, the paths of aggregate production and income.[1]

The dynamic problems focused on in this paper arise in the standard national-accounting framework because the setup is fundamentally static. The setting is not well grounded in intertemporal budget constraints and, therefore, does not handle appropriately the economic role of investment and capital stocks. These issues emerge clearly within a simple, well-known framework, the steady state of the neoclassical growth model. However, the results generalize beyond this setting. The key element of the model is its respect for intertemporal budget constraints.

I. Intertemporal Framework

The setup is standard, corresponding to the well-known infinite-horizon neoclassical growth model for a closed economy.[2] The representative agent's assets are held as internal loans (private bonds that aggregate to zero) or claims on capital, $K(t)$, which depreciates at the constant rate $\delta>0$. Perfectly competitive producers of goods produce output, $Y(t)$, using $K(t)$ and labor, $L(t)$, through a constant-returns-to-scale production function, $F(\cdot)$, which satisfies the usual neoclassical properties. Output divides in a one-sector-production-function setup between consumption, $C(t)$, and gross investment, $I(t)$.[3]

The representative agent's budget constraint at a point in time is:

$$(1) \qquad Y(t) = F[K(t), L(t)] = C(t) + I(t) = w(t)L(t) + R(t)K(t),$$

[1]For a recent survey of issues concerning measured product as a gauge of welfare, see Jorgenson (2018, section 5).
[2]This setup is often called the Ramsey model or the Cass-Koopmans model, following Ramsey (1928), Cass (1965), and Koopmans (1965). Cass and Koopmans generalized the models of Solow (1956) and Swan (1956).
[3]The focus here is on a closed economy without government. But *C* can include net imports and government consumption, *I* can include net foreign investment and public investment, and *K* can include net foreign assets.

where $w(t)$ is the real wage rate, equaling the marginal product of labor, and $R(t)$ is the real rental price of capital, equaling the marginal product of capital.[4] The real rate of return on capital and internal loans in this one-sector-production-function model is

(2) $$r(t) = R(t) - \delta.$$

The representative consumer chooses $C(t)$ over time to maximize overall utility. In the usual setup, as presented in Barro and Sala-i-Martin (2004, Ch. 2), the steady-state real interest rate is determined by parameters related to time preference and intertemporal substitution and by technical progress, typically assumed to be labor-augmenting. This technical change can be exogenous or endogenous. Correspondingly, the common steady-state growth rate of $Y(t)$, $C(t)$, $K(t)$, and $w(t)L(t)$ is a constant, $g\geq 0$, which is the sum of the constant growth rate of labor (corresponding to constant population growth) and the constant rate of technical progress. In a stochastic version of this model, the steady-state expected real rate of return on capital depends also on risk aversion and on parameters related to uncertainty in the production process.[5]

The present analysis simplifies by assuming that the expected real rate of return on capital, $r(t)$, is constant throughout at its steady-state value, denoted by r. The rate r exceeds the constant safe real interest rate by an amount that corresponds to the equity premium. More generally, r does not have to be constant and can be viewed as an average of present and expected future real rates of return on capital.

The intertemporal budget constraint for the representative household, starting from the current date t, is

(3) $$K(t) + \int_t^{\infty} w(T)L(T)e^{-r(T-t)}\, dT = \int_t^{\infty} C(T)e^{-r(T-t)}\, dT.$$

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[4]The uses of output in this one-sector model can be expanded to include perishable intermediate goods, which enter into production of final goods. The production function $F(\cdot)$ in equation (1) can then be viewed as applying to value added. This setup works exactly if intermediates enter in fixed proportions with gross output; for example, if an automobile always requires one ton of steel.

[5]See, for example, Barro (2009).

This constraint reflects the usual transversality or dynamic-efficiency condition, $r>g$. This condition ensures that the "terminal value" of $K(T)$ has a present value that asymptotes to zero as T tends to infinity.[6] Empirically, $r>g$ is satisfied if we measure r by the long-run average real rate of return on equity (not the safe real interest rate) and g by the long-run average growth rate of output or consumption. Reasonable values, discussed later, are r around 0.08 per year and g between 0.02 and 0.03 per year.

Assume to simplify that real labor income, $w(T)L(T)$ for $T \geq t$, always grows at its constant steady-state rate, g. If $L(T)$ corresponds to population, which grows at a constant rate, then the assumption is that $w(T)$ always grows at its steady-state rate, which reflects labor-augmenting technological progress. In this case, equation (3) simplifies to:

$$(r-g) \cdot K(t) + w(t)L(t) = (r-g) \cdot \int_t^\infty C(T)e^{-r(T-t)}\, dT. \quad (4)$$

If consumption, $C(T)$, also grew at the constant rate g (as it does in the steady state), the right side of equation (4) would simplify to $C(t)$. More generally, the right side can be viewed, in the spirit of Milton Friedman (1957, Ch.2), as "permanent consumption." Permanent consumption at time t is defined as the flow that, when growing at the steady-state rate g, has a present value equal to the actual one, $\int_t^\infty C(T)e^{-r(T-t)}\, dT$.

The perspective of the left side of equation (4) allows for an evaluation of three concepts of product or income, differing only by the rate of return associated with $K(t)$. The first is gross domestic product, Y;[7] the second is net domestic product, which equals national income, Y^n, for a closed economy; the third, labeled Y^*, can be viewed as "permanent income" (equal to the permanent

[6] See Barro and Sala-i-Martin (2004, p.93). Hulten (1979, p. 129) has an analogous condition for a finite-horizon setting.

[7] For an open economy, the corresponding measure is gross national product, which includes net foreign assets in $K(t)$. The labor $L(t)$ still refers to domestic residents if workers all work in their home country.

consumption mentioned before) and corresponds to the left side of equation (4). Hence, the suggested alternatives are:

(5a) GDP: $Y(t) = RK(t) + w(t)L(t) = (r+\delta)\cdot K(t) + w(t)L(t)$,

(5b) Net domestic product or national income: $Y^n(t) = (R-\delta)\cdot K(t) + w(t)L(t) = rK(t) + w(t)L(t)$,

(5c) Permanent income: $Y^*(t) = (r-g)\cdot K(t) + w(t)L(t)$.

A. Capital income and labor income

A natural measure of capital income is $rK(t)$, which enters along with labor income, $w(t)L(t)$, in national income, Y^n, in equation (5b). This concept uses r, the net real rate of return on capital, to gauge capital income, and the capital-income share of national income would be the ratio of $rK(t)$ to Y^n. The labor-income share of national income is then one minus the capital-income share. However, while this approach delivers meaningful results at a point in time, it does not work well in the context of the intertemporal budget constraint in equations (3) and (4).

If $K(t)$ is the capital stock at the current date t, then (with r constant) $rK(t)$ is the flow of consumption that could be sustained forever out of this capital stock. The present value of this flow is obviously just $K(t)$. In contrast, if $w(T)L(T)$ for $T\geq t$ is always growing at the constant rate g (where $0\leq g<r$), then $w(t)L(t)/(r-g)$ is the present value of consumption that can be sustained by the present and future flows of labor income. Therefore, in an intertemporal context, $K(t)$ and $w(t)L(t)/(r-g)$ are the comparable present-value objects. Or, in terms of flows, $(r-g)K(t)$ and $w(t)L(t)$ are the parallel income terms. That is, because $w(T)L(T)$ is growing for $T\geq t$, $w(t)L(t)$ counts more than one-to-one with $rK(t)$ in the intertemporal budget constraint. Specifically, with $w(T)L(T)$ growing at the constant rate g, the downward adjustment of $rK(t)$ to $(r-g)K(t)$ is the correct one. Therefore, the terms $(r-g)K(t)$ and $w(t)L(t)$ enter in parallel form into permanent income, $Y^*(t)$, in equation (5c). Thus, to compute a capital-income share from an intertemporal perspective, the natural measure is the ratio of $(r-g)K(t)$ to $Y^*(t)$. The labor-income share of permanent income is then one minus this capital-income share.

The assumed constancy of r and g is unimportant for the basic approach. More generally, r can be viewed as an average of current and expected future real rates of return on capital, and g can be viewed as an average of expected future growth rates of real labor income. The identification of r with the (constant) steady-state real rate of return and of g with the (constant) steady-state growth rate of real labor income are just approximations. However, these identifications do make the computation of permanent income in equation (5c) readily implementable from an empirical standpoint. Permanent income, $Y^*(t)$, is just the subtraction of $(\delta+g)\cdot K(t)$ from the standard GDP, $Y(t)$, in equation (5a), whereas national income, $Y^n(t)$, in equation (5b) is, as usual, the subtraction of $\delta K(t)$ from $Y(t)$. (In practice, these calculations would associate different values of δ with different types of capital.)

One approach that seems to have no economic rationale is the standard one that identifies capital income with $RK(t)$ in equation (5a). The capital-income share is then the ratio of $RK(t)$ to $Y(t)$, and the labor-income share is one minus this capital-income share. This calculation is not meaningful economically because R is a gross rental price that does not net out depreciation, at rate δ, to compute a net real rate of return on capital. Since $RK(t)$ is not a measure of net income, the ratio of these gross rental payments to $Y(t)$ is not an income share. Moreover, as discussed below, with reasonable parameters, this standard method sharply overstates the capital share of product and income. The computation of the capital-income share from national income also overstates the share from an intertemporal perspective but by not nearly as much as the share based on GDP.

B. Double-counting of product and income

As already noted, the only true final goods for households are consumption, $C(t)$, at various dates. Correspondingly, the intertemporal budget constraint for the representative household involves the financing of the present value $\int_t^\infty C(T)e^{-r(T-t)}\,dT$, which appears on the right sides of equations (3) and (4). Meaningful concepts of product and income should have a present value equal to

$\int_t^\infty C(T)e^{-r(T-t)}\,dT$.[8] The standard concepts of GDP and national income do not satisfy this condition because saving and investment are double-counted (to differing degrees).[9] As an example, suppose that a household receives one extra unit of labor income, $w(t)L(t)$, at time t. This unit appears one-to-one in the household's overall present value of income. But if this unit is saved (invested) at time t, the return on this savings appears again in future income and product. Hence, there is double-counting in the calculated present values.

To calculate the extent of double-counting, consider the full steady state, where $K(T)$ grows along with $w(T)L(T)$ and $C(T)$ at the constant rate g. In that case, the present values starting at date t of the three proposed concepts of income in equation (5) are:

(6a) GDP, Y: present value = $K(t)\cdot(r+\delta)/(r-g) + w(t)L(t)/(r-g)$,

(6b) National income, Y^n: present value = $K(t)\cdot r/(r-g) + w(t)L(t)/(r-g)$,

(6c) Permanent income, Y^*: present value = $K(t) + w(t)L(t)/(r-g)$.

The permanent-income concept in equation (6c) corresponds from equations (3) and (4) to the present value of $C(T)$, which grows in the steady state at rate g. Hence, for permanent income, there is no double-counting of saving and investment in the steady state.

In equation (6b), the double-counting for national income involves the term that includes $K(t)$. The excess of this term over $K(t)$ equals $K(t)\cdot g/(r-g)$. In the steady state, the $K(t)\cdot g$ part of this expression equals net investment, which grows at rate g in the steady state, and $K(t)\cdot g/(r-g)$ is the present value of this flow. Hence, the double-counting equals the present value of net investment. That is, the standard concepts of national income and net product count net investment once when it occurs and include the same present value again when adding up the future returns realized on this investment. Therefore, in the steady state, national income involves precisely double-counting of net investment.

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[8]The focus on the present value of consumption accords with the setup in Weitzman (1976).

[9]This result applies as much to an individual's intertemporal accounting as to national accounting.

In equation (6a), the double-counting for GDP involves the term that includes $K(t)$. The excess of this term over $K(t)$ equals $K(t)\cdot(\delta+g)/(r-g)$. In the steady state, the $K(t)\cdot(\delta+g)$ part of this expression equals gross investment, which grows at rate g in the steady state, and $K(t)\cdot(\delta+g)/(r-g)$ is the present value of this flow. Hence, the double-counting equals the present value of gross investment. That is, the standard concepts of GDP and the corresponding gross income count gross investment once when it occurs and include the same present value again when adding up the future gross returns generated by this investment. Hence, in the steady state, GDP exactly double-counts gross investment.

The proportional double-counting of GDP and national income in the steady state depend on the steady-state capital-output ratio, K/Y. To get quantitative insights on this ratio, suppose that the neoclassical production function $F(\cdot)$ in equation (1) is Cobb-Douglas with exponents α on K and $1-\alpha$ on L:

(7) $$Y = A \cdot K^{\alpha} L^{1-\alpha},$$

where $A>0$ and $0<\alpha<1$. Perfect competition among goods producers implies the equation of the gross marginal product of capital, given by $\alpha Y/K$, to $R=r+\delta$. This condition implies from equation (7) that K/Y is constant in the steady state and given by:

(8) $$\frac{K}{Y} = \frac{\alpha}{r+\delta}.$$

The difference between $Y(t)$ and $Y^*(t)$ from equations (5a) and (5c) implies that the flow of double-counting in GDP equals $(\delta+g)\cdot K(t)$. Using equation (8), the ratio of this double-counting to Y is constant in the steady state and given by:

(9) $$\text{Ratio of GDP double-counting to GDP} = \frac{\alpha\cdot(\delta+g)}{r+\delta}.$$

This double-counting is nil when $\delta=g=0$ (so that there is no gross investment in the steady state). As a quantitative example, suppose that $\alpha=0.40$, $\delta=0.09$ per year, $g=0.03$ per year, and $r=0.08$ per year.[10] In

[10]These parameters are motivated mostly by U.S. data. The value of δ is an average of the economic depreciation rates (weighted by "income shares") for the five categories of U.S. capital considered in Barro and Furman (2018, Table 3). The value for g corresponds to the long-run average growth rate of real GDP. (The U.S. long-term

this case, the ratio given in equation (9) equals 0.28.[11] That is, in the steady state with reasonable parameters, GDP overstates permanent income (and permanent consumption) by 28%.[12]

An analogous exercise applies to the double-counting ratio for national income. The result in the steady state is:

(10) Ratio of national-income double-counting to national income = $\frac{\alpha g}{r+\delta(1-\alpha)}$.

This double-counting is nil when *g=0* (so that there is no net investment in the steady state). Using the parameters noted above, we get that national income overstates permanent income in the steady state by 0.09. That is, in the steady state with reasonable parameters, national income overstates permanent income by 9%. Hence, the netting out of depreciation substantially reduces the over-counting of income (from 28% to 9%) but does not eliminate it.

C. Thoughts on the double-counting of product and income

The double-counting in product and income measures arises because these concepts include gross or net investment and also include the gross or net returns on past investments. Thus, for GDP in equation (1), *I(t)* appears in the middle of the equation, and the gross return on past investments, *R(t)K(t)*, enters on the right side of the equation. A reasonable idea is that the double-counting for GDP could be eliminated by excluding one or the other of these two terms.[13] Similarly, for national income,

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average of 0.035 is close to that, 0.030, for a group of 11 OECD countries with long-term data.) The value for α approximates estimates of Fernald (2014) for the United States in recent years. The value for *r* corresponds to an average of the (arithmetic) real rate of return on equity (0.081 for the United States, 0.073 for 11 OECD countries with long-term data) from an updated version of the numbers in Barro and Ursua (2008, Table 5). The underlying data come mostly from *Global Financial Data*. The calculated real rates of return are net of taxes levied on corporations; a value for *r* gross of business taxes (corresponding more closely to the marginal product of capital) would be higher. However, a lower value of *r* would be appropriate to allow for the influence of leverage on the rate of return on equity.

[11]With the assumed parameter values, the steady-state *K/Y* from equation (8) equals 2.4 (in units of years).

[12]An alternative is to look at the ratio of U.S. gross private fixed domestic investment to GDP—which averaged 0.17 from 1950 to 2018. However, this measure excludes public investment, which averaged 0.05 relative to GDP.

[13]To maintain the equality in equation (1), an adjustment to one term—*I(t)* in the middle or *R(t)K(t)* on the right—requires a corresponding adjustment in the other term.

one might think of eliminating either net investment, $I(t)$-$\delta K(t)$, or the net return on past investments, $r(t)K(t)$.

The first possibility is to define net income by omitting gross capital income, $R(t)K(t)$, in the measure of gross income on the right side of equation (1).[14] This exclusion implies that only labor income, $w(t)L(t)$, appears in net income. However, it is clear from equations (3) and (4) that the present value of labor income falls short of the present value of consumption. That is, the "initial" capital stock, $K(t)$, is a resource that should be included along with the present value of labor income when assessing possibilities for present and future consumption in the intertemporal budget constraint, as in equation (3). It may be that, in the far distant past, there was no initial capital (though that is unclear), so that only labor is an ultimate source of income and production.[15] However, once the economy has arrived at time *t*, prior costs of investment associated with the creation of $K(t)$ are sunk, and this initial capital stock should be regarded as a resource for financing consumption from time *t* into the future.[16]

The second possibility is to define net product by subtracting gross investment, $I(t)$, from gross product in the middle of equation (1). That is, all of investment would be 100% expensed at the time it occurs.[17] In this case, net product equals consumption, $C(t)$.[18] One attractive feature of this approach is

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[14]This procedure is effectively followed in the national accounts for government owned capital, which is assumed to have a positive estimated depreciation rate but a net real rate of return of zero.

[15]However, as is well-known, when the production function satisfies the standard neoclassical properties—as is true for the Cobb-Douglas form in equation (7)—no output can be produced when $K=0$.

[16]This viewpoint accords with Hulten's (1979) setup.

[17]The standard national accounts (BEA [2017], United Nations [2009]) take this approach for intermediate goods that last less than one year. This approach was also followed by the BEA for intellectual-property products until the revisions in 1999 and 2013 and by the United Nations until the revisions in 1993 and 2008.

[18]Consumption should be interpreted here as the sum of private and public consumption. As noted before, the identification of production with consumption accords with Kuznets (1941, p. 46). Yet, in defining net national product and national income, Kuznets (1941, p. 266) always included investment, net of estimated depreciation, as part of the production of final goods: "By final goods, we mean commodities and services in the form in which … they are used by ultimate consumers in households or by consumers of durable capital equipment in business and other economic enterprises. They include fully finished consumer goods reaching ultimate consumers, fully finished construction of all types, and durable capital equipment reaching the economic enterprises that use it in the production process. … The values of construction and durable equipment are net, i.e., the remainder left after an allowance has been made for the construction and equipment consumed during the year … " This Kuznets

that the present value of this definition of net product obviously equals the present value of consumption. Moreover, the identification of net product with consumption would be satisfactory if one limited attention to a steady state.

Outside of a steady state, the full expensing of gross investment in the definition of net product is problematic. Consider, as an example, a shift at time t between $C(t)$ and $I(t)$ for a given total of output, $Y(t)$, on the left side of equation (1).[19] This shift might be motivated by a temporary opportunity for investment or by a temporarily high or low value attached to consumption. Specifically, suppose that $C(t)$ declines and $I(t)$ rises for some length of time, so that the expanded capital stock allows for higher $C(T)$ in the future. The identification of net product with $C(t)$ would imply that current net product declines, although the present value of consumption dictated by the intertemporal budget constraint in equations (3) and (4) does not change. Thus, the full expensing of gross investment at each point in time implies that the proposed measure of current net product (i.e. current consumption) gives an inaccurate picture of intertemporal consumption possibilities outside of the steady state.

For permanent income, $Y^*(t)$, as defined in equation (5c), measured net product and income do not change when $C(t)$ and $I(t)$ shift at time t for given $Y(t)$. From the comparison with GDP in equation (5a), $Y^*(t)$ effectively applies 100% expensing only to the flow of gross investment, $(\delta+g)\cdot K(t)$, that arises in the steady state (or on average in the future when g is not precisely constant). This amount of expensing does not change at time t when $C(t)$ and $I(t)$ shift for given $Y(t)$.

The more general idea is that one would like a notion of current income that reveals, to the extent feasible, the possibilities for consumption in a full intertemporal sense. In the example just considered, to get the "right answer," one would have to factor in that the decline in current

procedure is consistent with the one established by Meade and Stone (1941), which later evolved into the U.N. System of National Accounts (SNA), described in United Nations (1993, 2009).

[19]The assumption is still that r is constant at its steady-state value and that $w(T)L(T)$ always grows at its steady-state rate, g. However, these conditions could be relaxed.

consumption, $C(t)$, is accompanied by a corresponding rise in the present value of (expected) future consumption, $C(T)$. This approach is not operational from a national-accounting perspective because it requires measurement at time t not only of $C(t)$ but also of (expected) future $C(T)$. Permanent income, $Y^*(t)$, as defined in equation (5c), works here because—by remaining unchanged[20]—it accurately reflects the reality that the present value of consumption is unchanged. Moreover, aside from knowing the parameters δ and g, the calculation of $Y^*(t)$ requires knowledge only of the current variables $Y(t)$ and $K(t)$.

In terms of practical measurement, it is worth stressing that, starting from the computed GDP, $Y(t)$, in equation (5a), the calculation of permanent income, $Y^*(t)$, in equation (5c) is a straightforward extension of the usual practice of deducting depreciation to compute net product or national income, $Y^n(t)$, as in equation (5b). That is, national income subtracts $\delta K(t)$ from $Y(t)$,[21] and permanent income in equation (5c) goes further to subtract "effective depreciation," $(\delta+g)K(t)$, from $Y(t)$. In other words, the effective depreciation rate is $\delta+g$, rather than δ, and the g part

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[20]In the example presented, the measured $Y^*(T)$ would rise over time, compared to its previous path, to reflect the boost to the capital stock, $K(T)$ for $T \geq t$, generated by the short-term cut in consumption. That is, by cutting consumption in the short run, the economy really can sustain a higher present value of consumption when calculated in the future.

[21]Kuznets stressed that estimating depreciation is crucial for computing net concepts of product and income but that the measurement of depreciation is difficult. (Much later, Hulten and Wykoff [1981] pioneered the use of observed prices of used capital goods of different vintages to infer depreciation rates.) Kuznets (1941, pp. 41-42) said: "What fraction of the durable capital good is consumed during the given period? The signs that would indicate that this or that fraction of a machine's total useful life or capacity has been absorbed are few. There are few reliable data even on total useful life and capacity. Consequently, estimates by business enterprises of current consumption of durable capital are exceedingly crude … The investigator must accept these estimates … To prevent distortion of the national income total and its distribution, estimates of intermediate consumption must be complete." In comparing net product with gross product, Kuznets (1937, p. 3) noted some advantages of the gross measures: "Of … several possible concepts of gross national product one appears of greater importance than the others, that in which the value of commodities and services produced is not adjusted for the value of durable capital goods consumed in the process of production, but is adjusted for raw materials, partly fabricated products and fuel consumed. It is this concept that is referred to … as gross national product … [which] has the advantage of being a variable that can be measured more accurately than net national product. More important is the fact that the replacement of durable capital goods in use by new commodities is not as rigidly controlled by technical considerations as is the replacement of raw materials … over short periods the stock of capital equipment may be treated as indestructible, and its consumption in the process of production neglected. … Consequently, in addition to net national product or national income, we also measure gross national product …"

corresponds to an average of expected future rates of economic growth. Just as the calculation of national income requires an estimate of the depreciation rate, δ, the calculation of permanent income requires also an estimate of the expected long-run economic growth rate, g. Empirically, the estimation of g actually seems less challenging than the estimation of δ (which, in practice, varies greatly across types of capital).

Note that, as long as the key parameters and measurement procedures are fixed, the double-counting problem affects computed levels of standard macroeconomic aggregates but need not affect growth rates, including the steady-state growth rate, g. In the steady state, all of the measures related to product and income—including real GDP, real national income, permanent income, capital stock, real labor income, and consumption—grow at the same rate, g.

The level effects are important, however, and do not involve merely a normalization for the calculated level of real GDP. The double-counting issue affects ratios of GDP or national income to consumption. For example, in the steady state, the ratio of *C* to GDP is:

$$\frac{C}{Y} = 1 - \frac{I}{Y} = 1 - \frac{(\delta+g)K}{Y} = 1 - \frac{\alpha\cdot(\delta+g)}{(r+\delta)}, \quad (11)$$

where the last result uses the formula for steady-state *K/Y* with a Cobb-Douglas production function from equation (8). The last term on the right side of equation (11) is the ratio of GDP double-counting to GDP, as contained in equation (9). This term reveals the proportionate extent to which *C* falls short of *Y* in the steady state; that is, it indicates by how much production (real GDP) proportionately overstates the resources available for consumption.

The level effects are also important for comparisons across countries. The central idea of the International Comparison Program (ICP) is to use estimated purchasing-power parities (PPPs) to construct levels of real per capita GDP that can be compared among countries at a point in time.[22] These cross-sectional comparisons would be affected by the double-counting issue if the problem were more serious in some countries than in others. Specifically, countries with higher capital-output ratios, K/Y—reflecting higher propensities to save and invest—would tend to have greater over-statement in levels of real per capita GDP. The "contribution" of saving and investment to a central measure of economic development—the PPP adjusted real per capita GDP—is, therefore, mechanically exaggerated.[23]

D. Capital-income shares

As mentioned before, income shares of capital and labor can be calculated corresponding to the three concepts of product and income in equation (5). The analysis here assumes the Cobb-Douglas form of the production function in equation (7).

For GDP (equation [5a]), capital's rental price, $R=r+\delta$, is equated to its gross marginal product, which equals $\alpha \cdot Y/K$. Therefore, as usual, the ratio of capital's gross rental income, $(r+\delta) \cdot K(t)$, to $Y(t)$ equals α, which was set at 0.40 in the previous examples. As noted before, this standard concept does not correspond to a capital-income share because gross rental income is not a measure of net income. However, if one takes seriously the Cobb-Douglas form of the production function, as in equation (7), then the standard "capital-income share" is interesting as a measure of the exponent α, which gives the elasticity of output, $Y(t)$, with respect to the capital stock, $K(t)$.

For national income, the income on capital in equation (5b) is $rK(t)$, which depends on the net rate of return, r, rather than the return gross of depreciation, $R=r+\delta$. The ratio of $rK(t)$ to national income, $Y(t)-\delta K(t)$, in the steady state can be determined to equal:

[22]This program was begun in 1968 as a joint venture of the United Nations and the University of Pennsylvania and is now directed by the World Bank in connection with the United Nations. For a conceptual discussion, see Summers and Heston (1991) and Feenstra, Inklaar, and Timmer (2015).

[23]This conclusion applies also to level comparisons across countries that are based on observed exchange rates, rather than purchasing-power parities.

(12) National-income capital share = $\frac{r\alpha}{r+\delta(1-\alpha)}$.

This share equals α when $\delta=0$ (in which case national income equals GDP, and net investment equals gross investment). Using the parameter values assumed before for r, δ, and α, the national-income capital share in equation (12) is 0.24, sharply below the standard number of $\alpha=0.40$.

For permanent income, the income on capital in equation (5c) is $(r\text{-}g)\cdot K(t)$. The ratio to permanent income, $Y^*(t)$, in the steady state can be determined to equal:

(13) Permanent-income capital share = $\frac{(r-g)\cdot\alpha}{r+\delta(1-\alpha)-g\alpha}$.

This share equals α when $\delta=g=0$ (in which case permanent income equals GDP, and net and gross investment are both zero in the steady state). Using the parameter values assumed before for r, δ, g, and α, the permanent-income capital share in equation (13) is 0.16, less than half of the standard share number of α=0.40.

E. Input-output tables

Another issue is that the treatment of investment as a final good affects the BEA's main input-output tables, which apply across industries.[24] Goods treated as perishable (materials and intermediates) show up in these tables as flows from one sector to another. Goods viewed as durable investments are treated instead as final goods, which appear, along with consumption, as a final-good use of products. The BEA does generate *Capital Flow Tables*, last produced for 1997, which provide an input-output analysis for newly produced structures, equipment, and software. These tables apply to investment, not to the flows of rental services on capital that would enter as inputs into production.

As discussed in the next section, the BEA revised its accounting procedures in 1999 and 2013 to capitalize some types of intellectual-property products. Before the revisions, these products—such as software and R&D—entered into the BEA's main input-output tables as flows of non-durable goods from

[24]For a discussion of these tables, see Young, et al. (2015).

one industry to another. After the revisions, these outlays were treated as final goods (investments) that no longer appeared in the flows across sectors.[25]

An alternative procedure would treat estimated rental services on durable investments, such as machines, as flows of services from one sector to another. These amounts would arise naturally if capital goods were literally rented by producers (say manufacturers of machines) to users (say construction companies or farmers). Importantly, these rental flows would not be contemporaneous with the investments themselves. Conceivably, the information that underlies the BEA's *Capital Use Tables* could be used to construct an input-output analysis of rental services.

II. Examples of Capital in the National Accounts

The model applies directly to several forms of capital in the national accounts, including business equipment and non-residential structures. Issues arise for other types of "capital." Remarkably, the standard treatment of investment and capital varies substantially across forms of capital and not in ways that are readily understandable from the viewpoints of economic concepts or practicalities of measurement.

The model can address issues with different forms of capital from an extension to allow for two types, K_1 and K_2. Hence, the Cobb-Douglas production function from equation (7) is extended to:

$$Y = A \cdot K_1^{\alpha_1} K_2^{\alpha_2} L^{1-\alpha_1-\alpha_2}, \tag{14}$$

where $\alpha_1>0$, $\alpha_2\geq 0$, and $0<\alpha_1+\alpha_2<1$. GDP now equals consumption, C, plus the two types of gross investment, I_1 and I_2. To simplify the algebra, the two depreciations rates, δ_1 and δ_2, are assumed to be the same and equal to δ. In this case, the prior results on double-counting of product and income and on capital shares continue to apply, with the substitution of $\alpha_1+\alpha_2$ for α in the various equations. If $\alpha_1+\alpha_2 = 0.40$, the value assumed before for α, the previous numerical results continue to hold.

[25]Xiang Ding brought this point to my attention.

A. Intellectual property

In the first application, K_2 is identified with intellectual property, a form of intangible capital. In its 1999 and 2013 revisions to the national accounts, the Bureau of Economic Analysis (BEA) included categories of intellectual property—software in 1999, research & development and artistic originals in 2013—as capital goods, analogous to equipment and structures.[26] Intellectual property is now a large item, constituting 26% of U.S. private fixed domestic investment in 2018. This category has grown significantly over time, from 4% of private fixed investment in 1950 and 10% in 1980 (see bea.gov).

Barro and Furman (2018, Table 3) estimated for 2017 that the intellectual property category constituted 29% of the standard measure of the total capital-income share of GDP, which corresponds to $\alpha_1+\alpha_2$ in equation (14). Therefore, the parameters $\alpha_1=0.28$ and $\alpha_2=0.12$ (which add to 0.40) should provide a reasonable approximation to the production-function parameters.

Suppose now that equation (14) represents the true production function throughout, but that the BEA changed its measurement in 1999 and 2013 to capitalize the investment expenses that underlie K_2. Capitalization for investments underlying K_1 applies throughout. The assumption is that the BEA is now generating "accurate" measures of the two gross investment measures, I_1 and I_2, and of the associated capital stocks, K_1 and K_2. However, prior to 1999, the BEA reported $I_2=K_2=0$; that is, outlays on intellectual property were treated as current expenses and were, therefore, netted out in the calculation of business value added.

In the old system, measured GDP equals $C+I_1$; that is, I_2 is excluded. In this sense, measured GDP understates true GDP. Recall, however, that true GDP is an overestimate not only of national income but also of permanent income, which is superior to GDP or national income as an intertemporal gauge of consumption possibilities. Therefore, it is possible (actually likely) that the improvement in

[26]Similarly, the U.N.'s 2008 System of National Accounts capitalizes some outlays on intellectual property products, including software, R&D, and artistic originals. See United Nations (2009).

measured GDP is accompanied by a worsening of measurement for purposes of gauging permanent income and consumption.

On the income side, the old system has labor income *wL* and rental income RK_1 arising from the first type of capital and treated here as observable. With this approach, a residual capital income attaches to the second type of capital, K_2—because this intellectual property is actually durable and productive but is not measured that way. Measured GDP in the old system is:

(15) $$measured\ GDP = C + I_1 = wL + \mathrm{R}K_1 + residual\ capital\ income_2.$$

True GDP (assumed to be measured in accordance with current BEA practice) includes I_2 and $\mathrm{R}K_2$ and is given by:

(16) $$true\ GDP = C + I_1 + I_2 = wL + \mathrm{R}K_1 + \mathrm{R}K_2.$$

Note that the factor incomes on the right side of equation (16) are assumed to exhaust the true GDP. Also, the factor prices, *w* and *R*, and the quantities, *C*, I_1, and K_1, are the same in the measured and true cases, given the assumption that BEA measurement choices affect nothing real. A further assumption is that the same rental price, *R*, applies to K_1 and K_2 (although differences in depreciation rates would create a divergence here).

The residual capital income of type 2 can be computed from equations (15) and (16) as:

(17) $$residual\ capital\ income_2 = RK_2 - I_2 = (r + \delta)K_2 - I_2.$$

In the steady state, I_2=(δ+g)K_2, and the expression on the right side simplifies to *(r-g)*K_2. Note that this expression for type-2 capital income takes exactly the form of the "net" capital income that enters into the definition of permanent income in equation (5c). That is, the old system of national accounts gets the right answer for the K_2 part of capital income in the steady state because it effectively expenses (nets out) the investment outlay I_2 in the measurement of GDP in equation (15). Outside of the steady state, however, this full expensing is problematic because it implies, along the lines discussed before, that a shift currently between *C* and I_2 would affect measured GDP in equation (15).

Another way to look at the results is that the revisions of the national accounts to capitalize intellectual property worsened the double-counting problem for GDP. The computations in Section I.B, based on a set of reasonable parameters and a Cobb-Douglas form of the production function, found that, in the steady state, the BEA's current procedure double-counted GDP when compared to permanent income and consumption by 28%. The pre-1999 BEA system avoided this problem with respect to the intellectual property part of investment and capital stock. Using parameters already described, including $\alpha_1=0.28$ and $\alpha_2=0.12$, the double-counting of GDP compared to permanent income in the steady state in the pre-1999 system turns out to be 20%, rather than 28%. To put it another way, the combined impact of the 1999 and 2013 revisions of the national accounts with respect to intellectual property is to worsen the double-counting problem by 8 percentage points.

The BEA's revised treatment of intellectual property also affects the computed capital-income share of GDP. This idea is stressed by Koh, Santaeulalia-Llopis, and Zheng (2018). In the BEA's current system, the usually calculated capital-income share is $\alpha_1+\alpha_2=0.40$. In the old system, in the steady state, type-2 gross investment, $(\delta+g)K_2$, is subtracted from GDP and from rental income. Therefore, the capital-income share of GDP in the steady state is

$$old\ system\ capital\ share = \frac{R\cdot(K_1+K_2)-(\delta+g)K_2}{Y-(\delta+g)K_2}$$

With the Cobb-Douglas form of the production function in equation (13), this result becomes:

$$(18) \qquad old\ system\ capital\ share = \frac{\alpha_1(r+\delta)+\alpha_2(r-g)}{r+\delta-\alpha_2(r+g)}.$$

Using the parameter values from before, this expression equals 0.33, as contrasted with the standard number of 0.40. That is, the combined 1999 and 2013 revisions in the BEA's measurement of intellectual property can "explain" a rise in the capital-income share of GDP from 0.33 to 0.40. This result accords roughly with the calculations in Koh, Santaeulalia-Llopis, and Zheng (2018, Figure 1).[27]

[27]Their results allow for comparisons of capital-income shares across concepts (for example, with or without capitalization of intellectual property investment) and over time within concepts.

Recall also that the permanent-income capital share in equation (12) is only around 0.16, far below either the old or new GDP-based values.

B. Home production and consumer durables

Not all aspects of standard national accounting generate over-statements of product and income from the perspective of gauging consumption possibilities. The most important sources of under-statement likely involve the neglect of most home production and the informal or black-market economy.[28] The BEA recognizes these sources of understatement of production and income and has tried to rectify this problem with respect to home production through the construction of "satellite accounts" that include estimates of the amount of this form of economic activity. (See Bridgman, et al. [2012] and Bridgman [2016].) This section deals with home production, though an analysis of the informal sector would be similar in form.

Household production involves consumer durables, including households' ownership of automobiles, furniture, appliances, and so on. Households' ownership of houses is treated differently in the national accounts, as discussed in the next section.

Suppose in equation (14) that K_1 represents capital goods used in the market (such as businesses' equipment and structures), and K_2 represents capital goods used in home production. The standard GDP comprises consumption of market goods, C_1; gross investment, I_1, in market capital; and gross investment, I_2, in home capital. The last item constitutes purchases of consumer durables and is

[28]Kuznets (1941, p. 20) argued for the exclusion of most non-market activities, including illegal transactions: " … of the net money receipts by individuals from ordinary market transactions or other sources the following are excluded: … products of illegal activities, such as smuggling, racketeering, bootlegging, and drug peddling." This measurement procedure is still followed in the United States; for example, the BEA (2017, p. 2-2) says: "… illegal activities, such as gambling and prostitution in some states, should in principle be included in measures of production. However, these activities are excluded from the U.S. accounts because they are by their very nature conducted out of sight of public scrutiny and so data are not available to measure them." In contrast with the U.S. procedure, estimates of the underground or informal economy and of illegal activity are included in GDP to some extent in some countries. For example, these activities are included in the formal setup of the U.N.'s System of National Accounts for 2008 (see United Nations [2009, Section 6.9ff and Ch. 25]).

included in the standard national accounts as part of personal consumer expenditure, rather than gross investment. Home production is assumed to go entirely to home consumption, C_2.

The standard GDP is generated by market capital and labor and is given as an extension of equation (1) by:

$$(19) \qquad Y_1 = F(K_1, L_1) = C_1 + I_1 + I_2 = wL_1 + RK_1.$$

Analogously, home production depends on home capital and labor and is given by:

$$(20) \qquad Y_2 = G(K_2, L_2) = C_2 = wL_2 + RK_2.$$

The production functions *F(·)* and *G(·)* satisfy the usual neoclassical properties. The change in each capital stock equals gross investment less depreciation, where the two depreciation rates are assumed to be the same and equal to δ. The assumption in equation (20) is that home labor and capital have associated shadow prices, *w* and *R*, that are the same as those of market labor and capital, respectively. This assumption would be valid if households can readily shift time and capital between home and market uses (ignoring taxes and assuming that time spent at market and home work are the same from a utility perspective). Note in equation (19) that measured GDP excludes home production and consumption, Y_2 and C_2, and gross income excludes home wage and rental income, wL_2 and RK_2.

As before, the market production function *F(·)* in equation (19) is assumed to be Cobb-Douglas with capital exponent α, as in equation (7). Going further, the home production function *G(·)* in equation (20) is also assumed to be Cobb-Douglas with capital exponent α. In this setup, which features equal capital intensities for producing market and home goods, the relative price of market and home consumption goods is fixed on the supply side, with the division between C_1 and C_2 determined only by preferences. In this case, the intertemporal budget constraint from equation (3) can be expressed directly in terms of total consumption, C_1+C_2:

$$(21) \qquad K_1(t) + K_2(t) + \int_t^\infty w(T) \cdot [L_1(T) + L_2(T)] e^{-r(T-t)}\, dT = \int_t^\infty [C_1(T) + C_2(T)] e^{-r(T-t)}\, dT.$$

If $w(T)L_1(T)$ and $w(T)L_2(T)$ each grow at every date at the steady-state rate g, equation (21) becomes (as an extension of equation [4]):

$$(22) \quad (r-g)\cdot[K_1(t)+K_2(t)] + w(t)\cdot[L_1(t)+L_2(t)] = (r-g)\cdot\int_t^{\infty}[C_1(T)+C_2(T)]e^{-r(T-t)}\,dT.$$

The left side of equation (22) equals permanent income, $Y^*(t)$, as discussed earlier. The difference between GDP and permanent income includes, as before, the difference between $RK_1(t)$ and $(r-g)\cdot K_1(t)$; that is, $(\delta+g)\cdot K_1(t)$. A new effect is that GDP excludes the home production terms, $(r-g)\cdot K_2(t)+w(t)L_2(t)$. The net amount of GDP over-counting can be written as

$$(23) \quad \text{GDP over-counting} = (\delta+g)\cdot[K_1(t)+K_2(t)] - Y_2(t).$$

The usual conditions for a steady state (with Cobb-Douglas production functions) give the capital-output ratios as $K_1/Y_1 = K_2/Y_2 = \alpha/(r+\delta)$, as in equation (8). These results imply that the GDP over-counting in equation (23) can be expressed relative to GDP, Y_1, as:

$$(24) \quad \text{(GDP over-counting)/GDP} = \frac{\alpha\cdot(\delta+g)}{(r+\delta)} - \left(\frac{Y_2}{Y_1}\right)\cdot\left[1-\frac{\alpha\cdot(\delta+g)}{(r+\delta)}\right].$$

In the steady state, $Y_2/Y_1 = K_2/K_1 = I_2/I_1$, and the last ratio can be calculated from numbers on purchases of consumer durables (I_2) and gross private fixed domestic investment (taken as a measure of I_1[29]). For example, for 2017, the ratio I_2/I_1 equals 0.42. In that case, with the previously used parameters ($\alpha=0.40$, $\delta=0.09$, $g=0.03$, $r=0.08$), the first term on the right side of equation (24) is 0.28, as before, and the second term is -0.30. Therefore, on net, GDP is under-counted by 2%; that is, the effect from the omission of home production slightly more than offsets that from the double-counting of investment.

An alternative procedure uses more detailed estimates of home production; for example, Bridgman, et al. (2012) and Bridgman (2016) estimate from data on household time-use and consumer durables that the ratio of U.S. home production to GDP was 0.37 in 1965 but only 0.23 in 2014.[30] Using

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[29]This concept includes residential investment. An alternative would be to use gross private non-residential fixed domestic investment.

[30]Bridgman, et al. (2012, p. 23) say: "The decline reflects the steadily decreasing number of hours households spent on home production. In 1965, men and women spent an average of 27 hours in home production, and by 2010, they

the recent value of 0.23 to gauge Y_2/Y_1 in equation (24),[31] the second term on the right side of the equation becomes -0.17. In this case, the net effect is an over-counting of GDP by 11%.

Although the consideration of home production and consumer durables has a major impact on GDP over-counting, it tends not to have major implications for the calculations of capital-income shares. In the case just presented, the "capital-income share" computed by expanding GDP to include estimated home production is still $\alpha=0.40$ (because home production is assumed to have the same capital intensity as market production). The capital-income shares associated with national income and permanent income are adjusted downward in the same way as before; that is, with the previously used parameters, they become 0.24 and 0.16, respectively.

C. Housing

Suppose now in equation (14) that the analysis treats K_2 as housing and neglects other forms of consumer durables. The variable Y_2, which equals C_2, now refers to household production of housing services. Unlike other consumer durables, the standard national accounts include in GDP and consumption the imputed rental income, RK_2, on owner-occupied housing.[32] The rental income on rental housing is also included in GDP. What is unclear is the treatment of home labor input, L_2,

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spent 22 hours. This overall decline reflects a drop in women's home production from 40 hours to 26 hours, which more than offset an increase in men's hours from 14 hours to 17 hours."

[31]However, the value 0.23 may be an under-estimate, because Bridgman (2016, p. 2) uses a low shadow wage rate to value household time used in home production: "The value of general services is the product of wage rate of general-purpose domestic workers and the number of hours of work." For many household members, the value of time would exceed the low wage rate received by domestic workers.

[32]This treatment appears in Kuznets (1941, p. 20). However, in an earlier analysis, Kuznets (1934, p. 12) suggested that it might be better to omit this item: " … there is some doubt as to the propriety of including this item [imputed net rental income accruing to people living in their own homes] since the ownership of a home combined with its possession does not constitute a participation by the proprietor in the economic activity of the nation in the same recognized fashion as does his work for wages, profit, or salary, or his capital investment in industry. For similar reasons, such an item as interest on durable goods owned has also been omitted." The BEA says that one motivation for its methodology on owner-occupied housing is "for GDP to be invariant when housing units shift between tenant occupancy and owner occupancy" (Mayerhauser and Reinsdorf [2007]). (GDP is not invariant to other shifts between renting or leasing and owning, such as for household automobiles and furniture.) The BEA procedure estimates the imputed rental income on owner-occupied housing by observing "rents charged for similar tenant-occupied buildings" (op. cit.). The owner-occupied housing part of housing services in personal consumer expenditure includes also outlays on maintenance & repairs, property insurance, and a few other items.

associated with the production of housing services. Most of the associated payments (or shadow payments), wL_2, would not appear in GDP—that is, the value of occupants' time expended on housing services would be excluded. This omission is likely to be greater for owner-occupied housing than for rental housing—if landlord-provided labor services (which appear in GDP) go beyond those purchased on the market by owner-occupiers (and, therefore, included in GDP). However, the assumption here is that wL_2 is fully absent from GDP in both contexts.

Because imputed or explicit rental income on housing appears in GDP, the expression for GDP over-counting in equation (23) no longer involves subtraction of the full home production, Y_2, on the right side. Instead, the subtraction involves Y_2-RK_2, which equals the unmeasured home labor income, wL_2. Again assuming Cobb-Douglas production functions (with the same capital intensities for market goods and for housing services), equation (24) is modified accordingly to:

(25) $$\text{(GDP over-counting)/GDP} = \frac{\alpha\cdot(\delta+g)}{(r+\delta)} - \left(\frac{Y_2}{Y_1}\right)\cdot\left[(1-\alpha) - \frac{\alpha\cdot(\delta+g)}{(r+\delta)}\right].$$

Note that the term $1\text{-}\alpha$ (corresponding to home labor earnings) appears within the brackets on the right side of equation (25), whereas the term *1* appears in the comparable position in equation (24).

In the steady state, $Y_2/Y_1 = K_2/K_1 = I_2/I_1$ again applies. The last ratio can now be calculated from numbers on gross private fixed domestic residential investment (I_2) and gross private fixed domestic non-residential investment (I_1). For example, for 2017, the ratio I_2/I_1 equals 0.31. In that case, with the previously used parameters ($\alpha=0.40, \delta=0.09, g=0.03, r=0.08$), the first term on the right side of equation (25) is 0.28, as before, and the second term is -0.10.[33] Therefore, on net, GDP would be over-counted by 18%. This net over-counting is larger than that associated with consumer durables because GDP includes the rental income on housing.

[33]If the production of housing services were more capital intensive than the production of market goods, the second term would be comparatively less important.

D. Inventories

Inventories comprise materials, goods-in-process, and finished goods. Net increases in stocks are classified as investment. Since inventories entail holding costs, a corresponding rental income associated with these holdings must appear in GDP. The rentals might reflect the benefit from having a larger stock available to meet customer demand (in the case of finished or nearly finished goods) or might represent cost reductions from employing a production process that allows large average holdings of materials, etc. (as opposed to a process that utilizes just-in-time inventory management).

Since GDP counts investment in inventories and also counts the rental income on stocks of inventories, the usual double-counting issue applies. However, because inventory change is, on average, a small fraction of GDP (0.55% from 1950 to 2018), the double-counting is minor when considered relative to GDP.

E. Government fixed capital

Denote by K_2 in equation (14) the amount of government owned capital. The new element here is that the national accounts allow for depreciation of public capital, δK_2, but assume a net real rate of return, r, of zero on this capital.[34] Hence, this treatment follows the suggestion mentioned before (but rejected) of excluding capital's net rental income, rK_2, from the calculated national income.

The associated over-counting of GDP equals $\delta K_2 – (r\text{-}g)K_2 = (\delta\text{+}g\text{-}r)K_2$. With the parameters used before, this term is positive. However, for national income, the over-counting equals $(g\text{-}r)K_2$, which is negative. That is, as discussed before, the deduction of net rental income from national income

[34]According to BEA (2017, p. 9-4): "Alternatively, BEA could augment its measure of capital services by including a net return on assets, a change that would tend to raise the overall level of government output and consumption expenditures, and thus GDP. Several approaches have been suggested: using a private sector rate of return, a municipal bond rate, the Office of Management and Budget hurdle rate for investment, or others."

constitutes an excessive adjustment and leads to an understatement of intertemporal consumption possibilities.

F. Human capital

This section is a sketch of how human capital would enter into the analysis. Formal schooling and on-the-job training contribute to human capital and, thereby, to higher labor productivity. The returns on this form of capital would show up in real GDP, though directly as income from labor, $w(t)L(t)$, rather than from capital. Human capital would also enter into home production. As with the implicit rentals on consumer durables, the implicit rentals on human capital used at home would not appear in measured GDP.

On the investment side, part of the outlays for accumulating human capital show up in GDP. Included here are costs of schooling, notably for teachers and school buildings. The bulk of these expenses appear in the national accounts as government consumption and investment and are valued at cost of production (including a net real rate of return of zero on government-owned capital). Another part of the expenditure on education involves private market purchases, and these outlays enter into the national accounts as personal consumer expenditure. An important omission on the expenditure side is the shadow value of student time used as an input into the educational process. From the perspective of GDP measurement, the omission of student time lessens the double-counting effect for human capital compared to that for physical capital.

For capital-income shares, a key issue is whether the returns to human capital should be construed as part of the income from labor or instead as part of the income from a broad concept of capital. The inclusion with labor income matches up with the simple observation that the income accrues to workers (in an amount consistent with the enhanced productivity derived from more human capital). However, the inclusion with capital income is appropriate from the perspective that the income reflects in part the services from a form of "capital," which is accumulated through a costly process of investment. In this respect, human capital and investments in this capital are analogous to physical capital and investments in that capital.

III. Observations

The basic structure of the national income and product accounts features double-counting of investment. Gross (or net) fixed investment counts once in gross (or net) domestic or national product when the investment occurs and a second time in present value when the cumulated capital leads to more gross (or net) rental income. This double-counting leads to over-statement of levels of aggregates such as GDP and national income; that is, measured product and income exaggerate sustainable consumption. The standard approach also over-states capital-income shares.

The over-counting problem is straightforward for businesses' equipment and structures but takes on different forms for other types of capital, such as intellectual property, household durables, housing, inventories, government capital, and human capital. As an example, the recent revisions of the national accounts to capitalize intellectual property resulted in substantial increases in reported levels of product and income and in capital-income shares. Thus, although reasonable for some purposes, the capitalization of investment flows for durable goods or ideas can sometimes deliver misleading results.

A tentative solution for the double-counting problem involves a form of full expensing for gross investment. The standard calculations of net product and national income feature deductions for depreciation of the existing capital stock. The purging of the remaining double-counting requires a further downward adjustment that reflects the long-term flow of net investment associated with the existing capital stock. In the steady state, this approach measures product and income by consumption, which corresponds to the full subtraction of gross investment from GDP. This general idea was raised long ago by Kuznets (1941, p. 46), who stressed that consumption was the only true "final good."

Outside of the steady state, the new concept of product and income differs from consumption because the full expensing relates to the long-run flow of gross investment, rather than the current flow.

At a practical level, the proposed concept seems implementable because it requires only an extension from the standard depreciation rate to an effective rate that adds in the economy's expected long-run rate of economic growth.

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