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Sustaining Economic Welfare: Estimating Changes in Wealth per Capita

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[1] The findings, interpretations and conclusions are those of the author, and are not to be attributed to the World Bank, its Board of Directors, or any of its member countries. This paper has its origin in discussions with Partha Dasgupta and David Pearce, who bear no responsibility for any errors in the result. Giles Atkinson, John Hartwick, Jed Shilling and Michael Ward provided useful comments on an earlier draft.

Abstract. 'Genuine' saving values the total change in economic assets and, as such, provides an indicator of whether an economy is on a sustainable path. New estimates of genuine saving from the World Bank broaden the usual national accounts definitions of assets to include human capital, minerals, energy, forest resources and the stock of atmospheric CO_2. The paper explores the issue of measuring changes in wealth per capita as a more comprehensive sustainability indicator which factors in both growth in total assets (as measured by genuine saving) and population growth. A theoretical approach to total wealth estimation is developed and first cross-country estimates of changes in wealth per capita are presented. Based on preliminary estimates, the conclusion is that the majority of countries below median income are in fact accumulating total wealth at a rate less than the rate of population growth.

Introduction

The 1999 publication of *World Development Indicators* (World Bank 1999) highlights for the first time the 'genuine' rate of saving for over 100 countries around the globe. As a more-inclusive measure of net saving effort, one that includes depletion and degradation of the environment in addition to the depreciation of produced assets, genuine saving provides a useful indicator of sustainable development. Hamilton and Clemens (1999) show for simple growth models that negative rates of genuine saving imply future declines in welfare along the optimal path for the economy (i.e., unsustainability by Pezzey's (1989) definition). Dasgupta and Mäler (forthcoming) show that this result carries over to non-optimal development paths for suitable definitions of the accounting prices of assets. In the real world these theoretical results imply the common-sense notion that sustained negative rates of genuine saving must lead, eventually, to declining welfare.

An important point in all of this, of course, is that it is *per capita* welfare that must be sustained. Genuine saving measures the change in total assets rather than the change in assets per capita. While genuine saving is answering an important question, therefore – did total wealth rise or fall over the accounting period? – it does not speak directly to the question of the sustainability of economies when there is a growing population. If genuine saving is negative then it is clear in both total and per capita terms that wealth is declining. For a range of countries, however, it is possible that genuine saving could be positive while wealth per capita is declining.

A simple formula makes this clear. Assuming that total wealth is not explicitly a function of population[2], then for total wealth W and population P it follows that,

$$\Delta\left(\frac{W}{P}\right)=\frac{W}{P}\left(\frac{\Delta W}{W}-\frac{\Delta P}{P}\right), \qquad (1)$$

where Δ represents the change in a variable over the accounting period (ΔW is therefore genuine saving, while ΔP is the total change in population). If the percentage change in total wealth is less than the percentage growth in population, total wealth per capita will fall.

The practical difficulty with expression (1) is that there are no widely available statistics on total wealth. Many (but not all) OECD countries publish national balance sheet accounts, which measure the total value of produced assets and commercial land. Virtually no developing countries publish these accounts. Moreover, to be useful as a sustainability indicator, the total wealth figures employed in expression (1) must be very broad, encompassing produced assets, commercial land, natural resources, and human and social capital. In *Expanding the Measure of Wealth* (World Bank 1997; see Kunte *et al.* 1998 for details) such a broad wealth measure was estimated for roughly 100 countries for 1994. However, these estimates are expensive to produce and are unlikely to be updated frequently[3].

[2] Atkinson *et al.* (1997) derive the more general expression when total wealth is a function of population.

[3] The genuine savings estimates published by the World Bank are kept up to date, but conceptual differences with the wealth estimates preclude simply updating the 1994 wealth estimates by accumulating the annual levels of genuine saving.

This paper will develop a conceptually sound approach to total wealth estimation, with the specific goal of estimating changes in wealth per capita. The analysis proceeds by presenting a formal model, followed by a detailed exposition of methodology using the United States as an example, followed by a presentation of results for 110 countries. The concluding section discusses some of the limitations of the methodology.

A Formal Model for Wealth Estimation

The System of National Accounts (SNA) approach to wealth measurement, and the approach adopted in part in *Expanding the Measure of Wealth* (World Bank 1997), is generally to place an economic value on individual assets and to add up the resulting values. In the realm of tangible assets this make eminent sense, but this presents problems to national accountants when assets are intangible. Moreover, it can be argued that the most important assets – human health, knowledge and skills, creativity, institutional and social capital – are precisely the least tangible.

The alternative to valuing and summing individual assets is to think more broadly about what we mean by wealth. The economist's answer to this question is clear: a useful measure of wealth would capture the *consumption possibilities* for the economy going forward. At the broadest, consumption should include not only ordinary goods and services, but the value consumers place on a variety of non-market flows of benefits as well (a beautiful view over a pristine environment, for example). However, in this context it is important to distinguish only those benefits that are not reflected in other market values measured in the national accounts.

The other issue in measuring wealth is to carefully distinguish consumption from investment. Ordinary national accounting treats as consumption many items that are, by their nature, clearly investments. The key examples of this are primary health care (the minimal expenditures required to repair daily wear and tear on the human organism), education expenditures, and outlays on research and development.

The simplest formal model available to deal with the question of wealth measurement is the Solow growth model. Assume there is a homogenous good that may either be consumed C or invested in capital K, and which is the output of a production function $F(K)$. Assume as well that population P grows exogenously at some fixed rate g. Then for *per capita* consumption c and capital k, the economic goal is to maximize the utilitarian maximand V as follows:

$$\max V_t = \int_t^{\infty} U\big(c(s), b(s)\big) e^{-d(s-t)} ds \text{ subject to } \dot{k} = F(k) - c \text{ for fixed rate of time preference } d .$$

Note that the utility function includes other per capita flows of benefits b in addition to those from consumption (this could include the benefits from environmental amenities, for example). Capital should be conceived very broadly to include natural resources, knowledge, skills, creativity and institutional and social capital.

The Hamiltonian function for this problem is given by $H = U + U_c \dot{k}$, while the efficient path for the marginal utility of consumption is described by: [4]

$$\frac{\dot{U}_c}{U_c} = d - F' \quad \Rightarrow \quad d + h(c)\frac{\dot{c}}{c} = F'. \tag{2}$$

Here $h(c)$ is the elasticity of the marginal utility of consumption. The right-hand portion of expression (2) serves to define the consumption rate of interest: the sum of the pure rate of time preference and the product of the elasticity of the marginal utility of consumption and the percentage growth rate of per capita consumption. In this idealized economy, with no risk or taxes, the consumption rate of interest is identically equal to the marginal product of capital.

From the left-hand portion of expression (2) it follows that,

$$U_{c(s)} = U_{c(t)} e^{d(s-t) - \int_t^s F'(k(t))dt}. \tag{3}$$

It is a general property of these equation systems that,

$$H = U + U_c \dot{k} = dV \quad \Rightarrow \quad U_c \dot{k} = \dot{V}. \tag{4}$$

Applying expression (3) and integrating the right-hand portion of expression (4) yields (up to a constant of integration),

$$k = \int_t^{\infty} \frac{U}{U_c} e^{-\int_t^s F'(t)dt} ds. \tag{5}$$

This is the desired result: a suitably expansive measure of wealth per capita is approximately equal to the present value of consumption per capita, where the discount rate is defined by the consumption rate of interest and consumption may include non-market benefits valued at marginal willingness to pay. If utility exhibits constant returns to scale, then this relationship is exact. In general, assuming non-increasing returns to scale in the utility function and declining marginal utility with respect to consumption and other benefits leads to the result that,

$$U \geq U_c c + U_b b,$$

which in turn implies that,

$$\int_t^{\infty} c \cdot e^{-\int_t^s F'(t)dt} ds \leq k - \int_t^{\infty} \frac{U_b}{U_c} b \cdot e^{-\int_t^s F'(t)dt} ds.$$

[4] Dasgupta and Mäler (forthcoming) show that the results in this section hold for any arbitrary development path as long as the same efficiency condition for the marginal utility of consumption holds along the path.

Here U_b/U_c is the marginal willingness to pay for a unit of benefit *b*. Under plausible assumptions about the utility function, therefore, the present value of consumption per capita is a lower bound for total wealth per capita.

The empirical issues in wealth estimation can be explored through the simple case where consumption per capita *c* grows at a fixed rate *r* and where the elasticity of the marginal utility of consumption h is also assumed to be fixed. Then,

$c = c_0 e^{rt}$, so that,

$$k = \int_t^\infty c_0 e^{-[d+(h-1)r](s-t)} ds = \frac{c_0}{d+(h-1)r}.$$

This estimate of wealth is feasible if $h > 1 - d/r$, and so if $r > d$ there is a positive lower bound on h.

As expected, $\partial k/\partial d < 0$, so that wealth declines as the pure rate of time preference increases. However,

$$\frac{\partial k}{\partial r} < 0 \text{ if } h > 1.$$

If the elasticity of the marginal utility of consumption is larger than 1, the result is that total wealth is a declining function of the growth rate in per capita consumption – the intuition behind this, of course, is that declines in marginal utility more than offset the effects of growth. If $h = 1$, then *k* is independent of *r*.

The case for wealth per capita as a sustainability indicator rests on the right hand portion of expression (4). If the change in wealth per capita is negative, then the present value of welfare also declines, which in turn implies that the development path is not sustainable. Note that,

$$\dot{k} = \frac{d}{dt}\left(\frac{K}{P}\right) = \frac{K}{P}\left(\frac{\dot{K}}{K} - \frac{\dot{P}}{P}\right) = \frac{K}{P}\left(\frac{\dot{K}}{K} - g\right).$$

This just restates expression (1) in continuous time. $\dot{K}$ is genuine saving.

This model can be made more elaborate, by including a range of natural resources, pollution stocks, notional asset values for R&D and human capital, and so on. But these elaborations would yield little that is new, in the sense that a variation on expression (5) will continue to hold: the sum of these appropriately priced assets would still equal the present value of an expanded consumption measure, discounted at the consumption rate of interest.

Detailed Methodology Applied to the United States

Both informal thinking about wealth and the formal growth model suggest that a good estimate of wealth can be provided by the present value of forecasted consumption per capita. However, constructing such a wealth estimate necessarily involves combining a large number of assumptions. What follows is an exposition of these assumptions and a sensitivity analysis of the wealth measures derived therefrom, using US data for 1997 as an example. All data are taken from *World Development Indicators 1999* (hereafter WDI).

As suggested by the formal model, the approach to wealth estimation is to construct an estimate of the present value of consumption. The appropriate discount rate for this calculation is the consumption rate of interest. Many of the key steps in deriving the estimate pertain to careful consideration of what is truly consumption, and what investment. The consumption and genuine saving figures are then adjusted to reflect these considerations, leading to the calculation of estimated wealth. For consumption C as measured in the SNA, adjusted consumption C^*, genuine saving G, and total wealth W, the calculation proceeds as follows:

$$G = GDP - C - Depreciation - Depletion + Education + PrimaryHealth + R\&D$$

$$C^* = C - Education - PrimaryHealth - R\&D$$

$$W = \sum_{t=0}^{24} \frac{C^*}{(1+i)^t}$$

Here i is the consumption rate of interest. These estimates are then plugged into expression (1), along with the percentage growth in population, to yield the change in wealth per capita.

Table 1 lays out the key variables for the wealth estimate and a series of variants on this estimate. Alternative values for the components of the consumption rate of interest are compared to a study for the UK by Pearce and Ulph (1994). Notes on each element of the table follow:

Health investment / capita. The US spent roughly $4,100 per capita on health care in 1997 and it can be argued that a substantial proportion of this was consumption rather than investments in "care and maintenance." The assumed value of $250 per capita as investment is roughly equal to per capita spending in upper middle income countries, as reported in WDI. *Variant A* looks at the effect of an assumed per capita health investment of $500.

Consumption / capita. This is the national accounts figure for public and private consumption, adjusted as follows. First, education expenditures (5.8% of GDP) are subtracted from consumption (they are already included in genuine saving). Next, R&D expenditures are apportioned to investment (0.5% of GDP), and public and private current expenditures (1.0% of GDP each). Total current expenditures on R&D are added to genuine saving, while current public expenditures are subtracted from consumption. As just noted, health investments are subtracted from the national accounts measure of consumption and added to genuine saving.

Genuine saving / capita. Net domestic saving is adjusted to reflect natural resource depletion[5], CO_2 damages and investments in education (this is the genuine saving figure reported in WDI). The adjustments and reclassifications mentioned under 'consumption / capita' above are then applied to arrive at a final measure of genuine saving.

Per capita consumption growth rate. This is the average growth rate of private consumption from 1980 – 1997.

Table 1. Central wealth estimate and variants, United States, 1997.

	Central	A	B	C	D	E
Health investment / capita	$250	***$500***	$250	$250	$250	$250
Consumption / capita	$22,300	$22,000	$22,300	$22,300	$22,300	$22,300
Genuine saving / capita	$3,900	$4,100	$3,900	$3,900	$3,900	$3,900
Consumption growth / capita	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%
Rate of time preference	1.5%	1.5%	***1.2%***	1.5%	1.5%	1.5%
Elasticity of MUC	1.0	1.0	1.0	***0.8***	1.0	1.0
Consumption rate of interest	3.4%	3.4%	3.1%	3.0%	3.4%	3.4%
Population growth rate	0.8%	0.8%	0.8%	0.8%	***1.0%***	0.8%
Lifetime (for PV)	25	25	25	25	25	***30***
Wealth / capita	$462,000	$456,000	$479,000	$485,000	$462,000	$535,000
Change in wealth / capita	$322	$612	$190	$145	($742)	($243)
Change %	0.07%	0.13%	0.04%	0.03%	-0.16%	-0.05%

Source: author's estimates. MUC: marginal utility of consumption. Figures are rounded.

Rate of time preference. This is the pure rate at which people discount future welfare. Estimates for the UK in Pearce and Ulph (1995) vary from 0 to 1.7%, with their 'best' estimate being 1.4%. The central assumption here is 1.5%, with *Variant B* reflecting the effects of an assumed level of 1.2% for this variable – this is the median figure estimated by Lawrance (1991) using panel data of US income data covering 1967-71.

Elasticity of the marginal utility of consumption. Pearce and Ulph report UK values in the range of 0.7 to 1.5, with a best estimate of 0.8. The central value used here is 1.0 (which renders the calculation insensitive to the consumption growth rate), while *Variant C* sets the MUC to 0.8.

Population growth rate. Population growth of 0.8% per year is the average of the observed rate over 1980 – 1997 and the projected rate from 1997 – 2015 as reported in WDI. This serves as a 'neutral' estimate of current population growth rates. *Variant D* uses a rate of 1%, which is the observed growth rate over 1980 – 1997.

[5] The resources covered include oil, natural gas, coal, bauxite, copper, iron, lead, nickel, phosphate, tin, gold, silver and timber (net depletion). Soil degradation, subsoil water and fisheries are excluded for reasons of data availability.

Lifetime over which the present value is calculated. The central value used is 25 years, while *Variant E* uses a value of 30 years.

Discussion

There is a clear sensitivity of the change in wealth per capita to the population growth rate. The results in Table 1 suggest that US growth in wealth per capita is on a knife edge – if population growth does not slow as assumed in the population projections, then wealth per capita (Variant D) could actually be marginally declining. This may appear to be surprising, given the recent performance of the US economy, but it simply reflects the interplay between a relatively weak savings effort and sizeable population growth. In the case of the US, foreign borrowing has arguably helped finance an extraordinarily productive capital stock, supporting the observed levels of consumption. But the fact that the current account deficit has been between 1 and 3 percent of GDP continuously since 1982 suggests that there are bills to be paid.

On the question of health investment expenditures, it would be valuable to dig more deeply into health data in order to arrive at a defensible measure of primary health care spending. Figures higher than $250 per capita per year appear questionable, however – World Bank (1993) estimates that $12 / capita / annum is the expenditure required to supply minimum preventative and essential clinical services in developing countries.

The elasticity of the marginal utility of consumption can be interpreted as a measure of aversion to consumption inequality (either between social groups or across time). The central figure of 1.0 implies that, for two households with consumption varying by a factor of two, the utility provided by an extra dollar of consumption is twice as high in the low-consumption household as in the high. This is a fairly egalitarian assumption. It is difficult to argue for higher (more egalitarian) values of the elasticity of MUC and, moreover, this would lead to the perverse result highlighted in the preceding section, where higher growth rates in per capita consumption would lower the estimated wealth. Lower values of the elasticity of MUC lead to higher wealth estimates, as seen in Variant C.

The question of the lifetime over which to calculate present values has no obvious ‘right’ answer. The formal model suggests taking the present value to infinity, but it is implicitly assuming infinitely-lived assets as well. The central value, 25 years, corresponds roughly to the length of a human generation and to the service life of relatively long-lived produced assets. Any argument for longer lifetimes will clearly tend to increase estimated wealth and decrease the change in wealth per capita.

Aside from the variables affecting the wealth calculation, it is worth commenting on the genuine saving estimates as well. As reported in the WDI, there is reason to believe that depletion of exhaustible resources is overstated by the chosen methodology of estimation. On the other hand, there are two clear lacunae which imply that genuine saving is over-stated. First, human capital is not depreciated in the World Bank estimates. Second, local pollution damages are not calculated – this is likely to be particularly serious for pollutants such as particulate

matter (PM10) and SOx. On balance, genuine saving may be over-estimated by several percent of GDP in many countries.

Cross-Country Wealth Estimates

To examine the question of changes in wealth per capita across the globe, the wealth estimation methodology of the previous section, including central values of all parameters and capping primary health care expenditures at $250 per capita, was applied to 110 countries – these represent the countries for which sufficient data are available from WDI. Table A1 at the end of this paper presents the results for all countries for 1997. The remainder of this section summarizes the information in Table A1 in order to shed further light on these results.

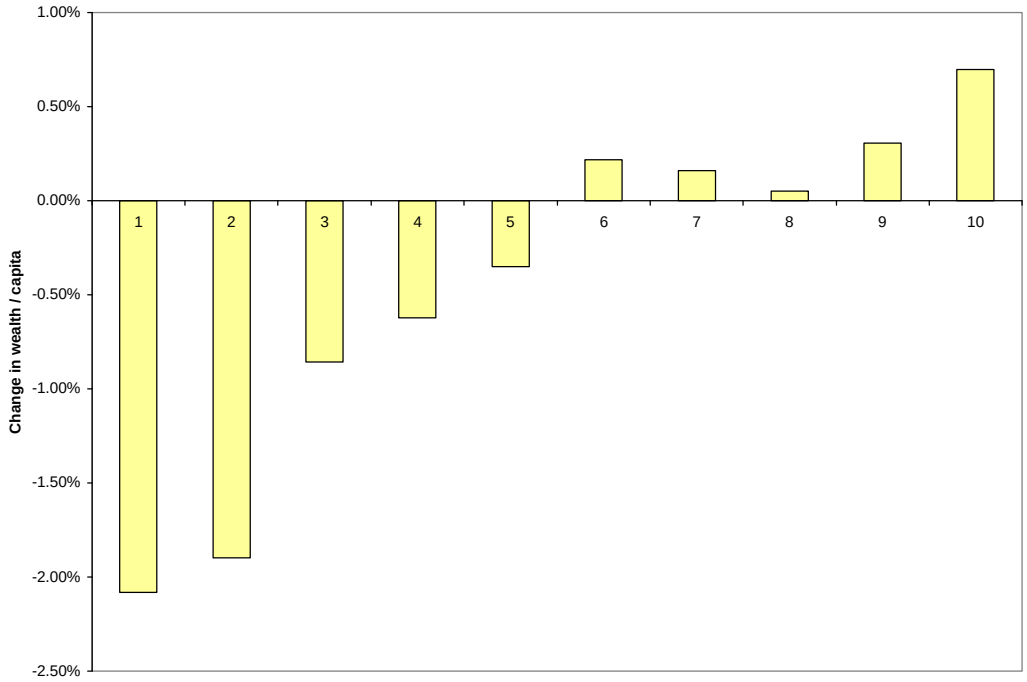
Alternative estimates of changes in wealth per capita are shown in Table 2. The first columns summarize the results by nominal income (GDP per capita) deciles for all countries using a constant pure rate of time preference (RTP) of 1.5%. It is reasonable to assume that poorer countries in fact have higher rates of time preference – this would be consistent with the generally lower saving rates in poor countries – but there appear to be no cross-country estimates of RTPs for developing countries in the literature. A rough approximation to income-dependent RTPs is therefore derived from the Lawrance (1991) panel study using US income data. Lawrance finds that RTP varies by a factor of 2.44 from the first decile to the tenth (from 2.2% to 0.9% with a median, as noted earlier, of 1.2%). This same ratio is then applied to cross-country income deciles to arrive at the 'central' wealth estimates reported in the middle columns of Table 2 (this corresponds to RTP varying from 1.5% in the highest decile to 3.66% in the lowest, with equal steps in RTP across deciles). Because the variation in income deciles across countries is higher than for US income groups (cross-country income deciles vary by a factor of 35 in purchasing power parity (PPP) terms), a third variant is summarized in the final two columns of Table 2, corresponding to a maximum RTP of 5% in the lowest income decile.

Table 2. Wealth per capita and percentage change by income deciles, 1997.

	RTP = 1.5%		Central estimate RTP → 3.66%		RTP → 5.0%	
	Wealth / capita $	Change in wealth / capita	Wealth / capita $	Change in wealth / capita	Wealth / capita $	Change in wealth / capita
1	3300	-2.19%	2600	-2.08%	2200	-2.01%
2	5300	-1.96%	4300	-1.90%	3800	-1.86%
3	6200	-1.02%	5100	-0.86%	4600	-0.75%
4	8500	2.00%	7200	2.55%	6500	2.92%
5	17500	-0.52%	15200	-0.35%	14000	-0.24%
6	31600	0.04%	28200	0.22%	26400	0.33%
7	43800	0.09%	40200	0.16%	38200	0.21%
8	65600	-0.04%	62000	0.05%	59900	0.10%
9	211900	0.30%	210300	0.31%	209400	0.31%
10	414100	0.70%	414100	0.70%	414100	0.70%

Rates of time preference of 3.66% or 5% represent very high rates of impatience, and it is not clear that detailed study of time preference rates in developing countries would bear out these assumed rates. Nevertheless, the conclusion from Table 2 is that the broad result, negative changes in wealth per capita in the five lowest income deciles, is robust for varying rates of time preference. There is only one sign change, for decile 8, and it is small. China with its enormous size and robust savings rate completely dominates the result for decile 4 – if China is dropped from the sample then the central estimate displays the changes in decile wealth per capita shown in Figure 1, while the mean wealth per capita in decile 4 rises to $10,700 (all wealth figures are rounded to the nearest $100 in what follows).

Figure 1. Change in wealth per capita by income decile, 1997, excluding China.

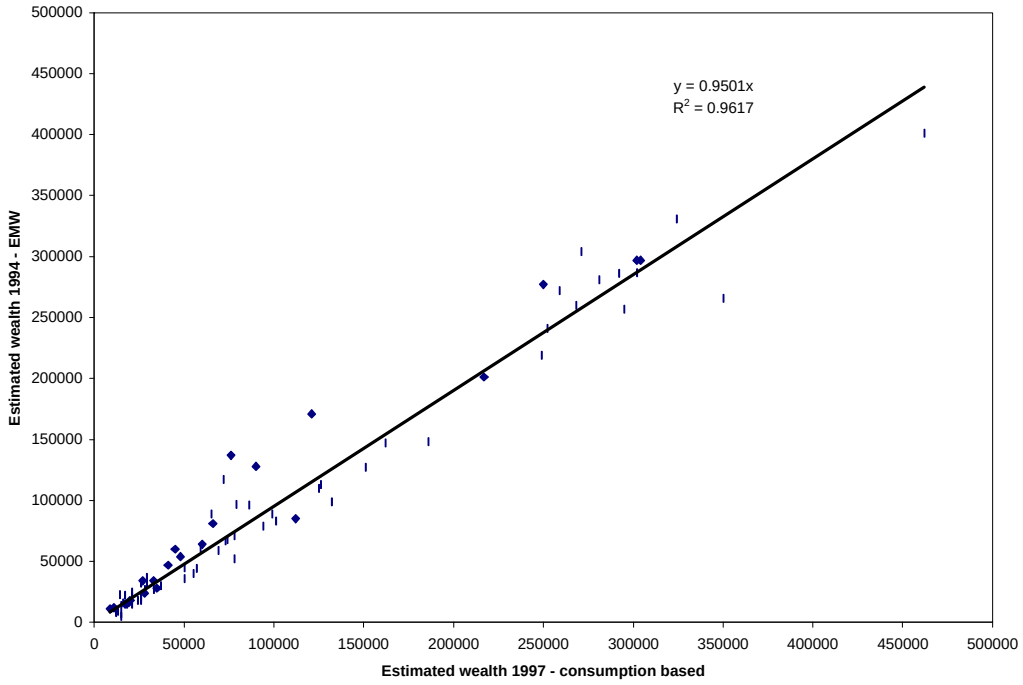


These results can be compared with the 1994 total wealth estimates published in *Expanding the Measure of Wealth* (EMW) (World Bank 1997) and detailed in Kunte *et al.* (1998). While the methodological emphasis in this earlier work was on detailed estimation of natural resource wealth for roughly 100 countries, the total wealth estimates were dominated by 'human resources' as an asset class, constituting over 60% of the wealth of most nations. The value of human resources was estimated as a residual by eliminating the returns to natural resources and produced assets from GNP; this residual was then valued at PPP exchange rates and converted to a stock by taking the present value of this flow over the remaining years of life of the population (life expectancy at age one capped at 65 years, minus the mean age of the population) using a social discount rate of 4% for all countries.

Figure 2 scatters the consumption based wealth estimates (for constant RTP of 1.5% and converted to PPP dollars) against those for 1994 in EMW. The fitted line has a slope of 0.95 (to

be expected since nominal wealth in 1994 is being compared with that in 1997) and an R^2 of 0.96. Some notable outliers aside, there is clear comparability of the results. Not too much should be made of this similarity, however, given the dominance of the human resources asset class in the EMW estimates.

Figure 2. Consumption based wealth estimates compared with *Expanding the Measure of Wealth*.



To give some idea of the range in the wealth estimates, Table 3 summarizes the results on changes in wealth per capita for the highest and lowest 10 countries appearing in Table A1[6]. Note that Saudi Arabia has been eliminated from the lowest 10, owing to the likelihood of a large under-estimate of genuine saving in this country, while Botswana has been eliminated from the highest 10 because of the lack of data on diamonds (and the corresponding over-estimate of genuine saving).

[6] Table A1 and all of the results to follow pertain to the 'central' wealth estimate described in Table 2.

Table 3. Low and high growth in wealth per capita, 1997.

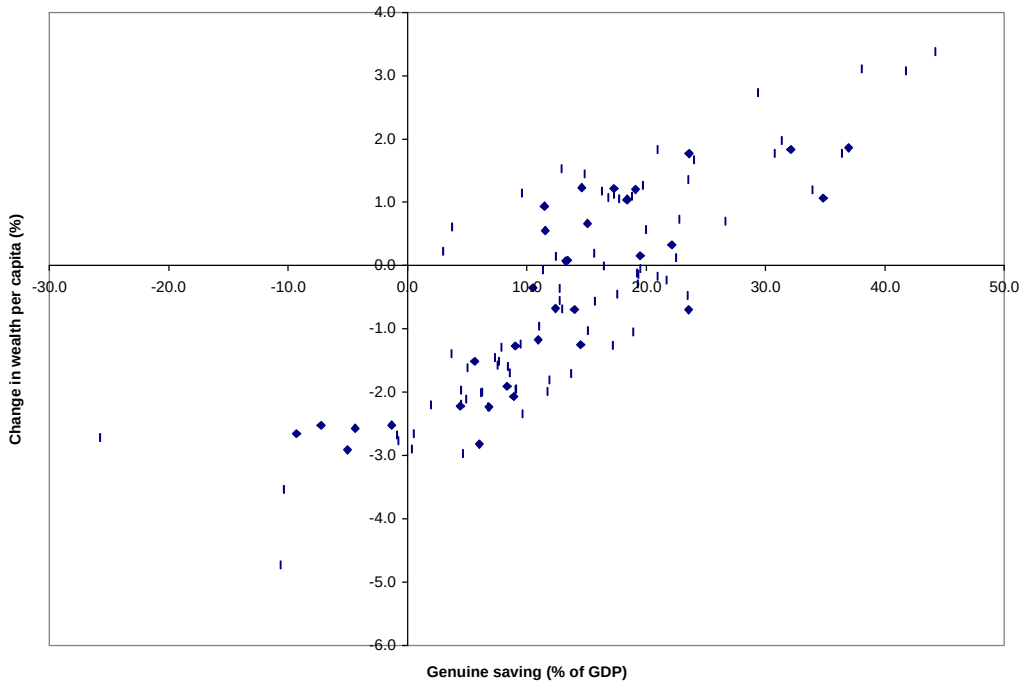
	GDP / capita $	GDP growth rate 1990-97, %	Population growth rate %	Genuine Saving % of GDP	Wealth / capita $	Change in wealth / capita, $	Change in wealth / capita, %
Nigeria	338	2.8	2.7	-10.4	4300	-152	-3.5
Jordan	1581	6.3	3.3	4.6	23800	-707	-3.0
Mauritania	446	4.2	2.5	-5.0	6100	-178	-2.9
Gambia, The	345	2.2	2.9	0.3	5000	-145	-2.9
Niger	189	1.5	3.2	6.0	2700	-76	-2.8
Chad	224	4.6	2.7	-0.8	3500	-97	-2.8
Azerbaijan	579	-15.1	1.0	-25.8	8600	-234	-2.7
Malawi	245	3.6	2.6	-0.9	3600	-96	-2.7
Sierra Leone	173	-4.4	2.1	-9.3	2800	-74	-2.7
Syrian Arab Rep	1202	6.3	2.7	0.5	15600	-415	-2.7
Slovak Republic	3615	0.6	0.3	23.6	41300	730	1.8
Malaysia	4545	8.6	2.1	36.3	42300	749	1.8
Thailand	2540	7.4	1.1	30.7	27100	481	1.8
Czech Republic	5050	-0.2	-0.1	20.9	60000	1097	1.8
Korea, Rep.	9622	7.2	0.9	32.1	113900	2091	1.8
Panama	3032	4.8	1.6	36.9	32300	600	1.9
Ireland	20494	7.0	0.5	31.3	254300	5027	2.0
Hungary	4503	-0.2	-0.3	29.4	54600	1491	2.7
Singapore	31036	8.5	1.4	41.7	290900	8942	3.1
China	735	11.6	1.0	38.0	6800	212	3.1
Avg (110 countries)					72900		-0.1

Note: Saudi Arabia and Botswana have been omitted from this table.

The countries with the greatest loss in wealth per capita in Table 3 are from sub-Saharan Africa and the Middle East, with Azerbaijan as the lone Central Asian example (owing to a weak saving effort and substantial depletion of oil resources). The countries with the greatest increase are East Asian and Central European, with Ireland standing out as the lone high income OECD country. Note that the genuine savings numbers in this table, and in Table A1, differ from those published in WDI because of the further adjustments made for primary health and R&D investments.

Four of the negative wealth growth rate countries in Table 3 have positive genuine savings rates, which relates to the question posed at the beginning of this paper: tracking changes in total wealth through genuine saving may not reveal an underlying decline in wealth per capita. Figure 3 provides a more comprehensive view of this phenomenon.

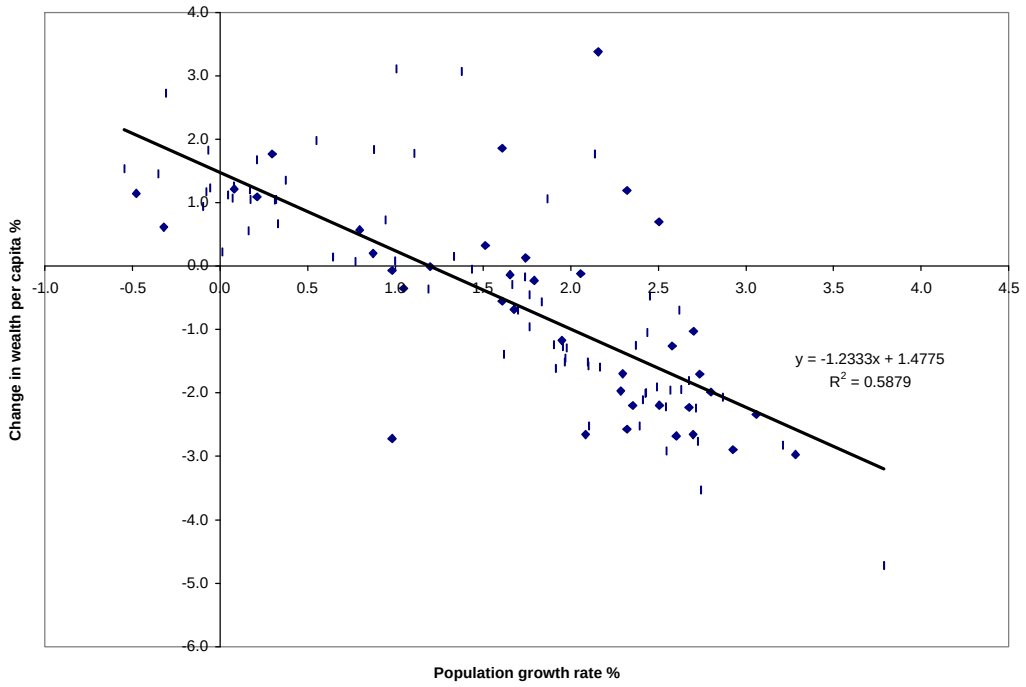
Figure 3. Relationship between genuine saving and change in wealth per capita.



The upward slope of the scatter in Figure 3 is unsurprising. The lower-right quadrant of the figure suggests that there are many countries with positive genuine saving but declining wealth per capita. Broadly speaking, genuine saving rates of less than 10% of GDP entail a very high likelihood of declining wealth per capita, while rates in excess of 25% are generally associated with increasing wealth per capita. For genuine saving rates in between these limits, the results are highly variable and, presumably, specific to country conditions.

Less apparent in Table 3 is the variation in growth rates in wealth per capita with population growth rates. This is displayed in Figure 4.

Figure 4. Relationship between growth rates of wealth per capita and population.



As expected, this relationship is negative. The elasticity of 1.23 suggests that there is a tendency for high population growth rates to be associated with negative genuine saving. For population growth rates in excess of 1.23% there is a high likelihood of negative growth in wealth per capita.

The final points to note from Table 3 concern the average for wealth per capita and its growth for all 110 countries in the sample. The average wealth per capita, $72,900, is higher than the value for the 8th decile in Table 2 – the wealth distribution is highly skewed, in other words. Secondly, the average change in wealth per capita is marginally negative. Across the world, these results suggest that aggregate wealth growing is slightly more slowly than total population.

In terms of the individual country results in Table A1, a few results are worth commenting upon. As noted earlier, Botswana tops the list in terms of growth in wealth per capita, but this is overstated because, owing to data limitations, there is no depletion of diamonds in the genuine saving calculation. Other notable African countries are Ghana and Uganda at -2.2%, and South Africa at -0.7%. The Latin American giants, Brazil, Mexico and Argentina, all display minor declines in estimated wealth per capita. Several Eastern European countries show increasing wealth per capita, such as Bulgaria and Estonia at 1.5%, but this is partly due to declining population. Along with Ireland, the other high-income OECD country to stand out is Australia, with its moderate decrease in wealth per capita – this reflects low savings, high mineral depletion and relatively large population growth.

Discussion and Conclusions

The interplay of capital accumulation and population growth leads, according to the methodology developed in this paper, to a wide range of developing countries where wealth per capita is in fact declining. To judge this result, it is essential to discuss some of the limitations of the methodology applied.

The most obvious potential weakness in the method is that it does not proceed, asset by asset, by adding up distinct components of national wealth such as buildings, machinery and equipment, infrastructure, commercial land, natural resource stocks, and so on. This is a fair criticism, but it ignores the evidence that the major part, perhaps 60-70% or more, of value added in GDP comes from factors other than these assets, including human capital, creativity, and social and institutional capital.

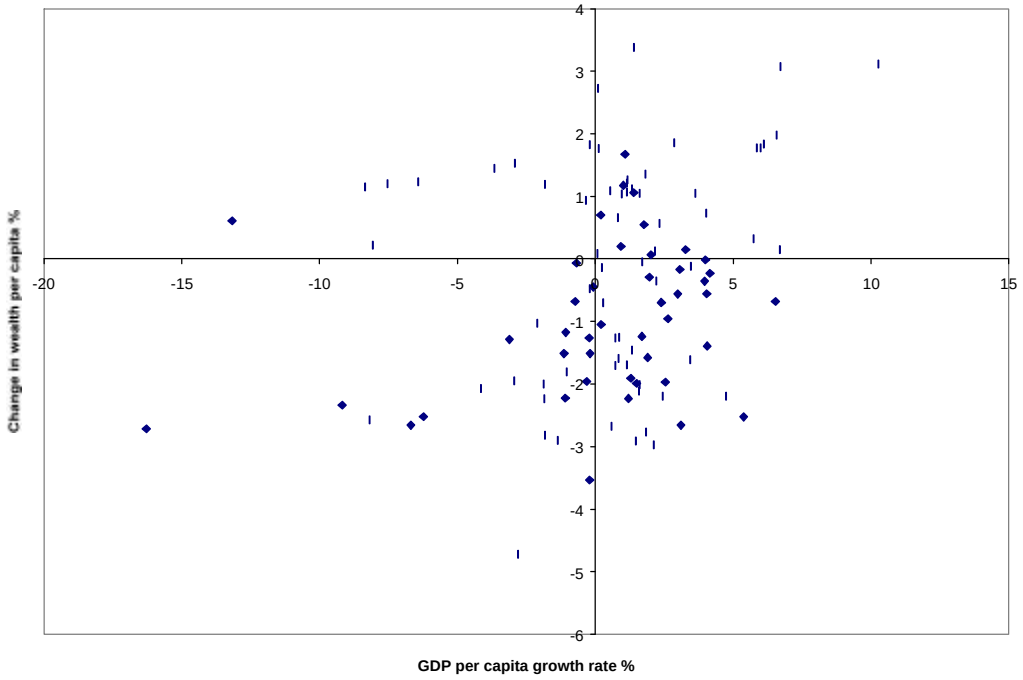
A further conclusion from Table 2 is that the finding of negative growth in wealth per capita in the lowest income deciles holds over a wide range of wealth estimates. For decile 1 for example, varying the rate of time preference leads to a 33% decrease in wealth, but only a very marginal change in the percentage decline in wealth per capita. In other words, the percentage change in wealth is completely dominated by the population growth rate. This could be viewed as a robust result if there were clear evidence that the estimates of total wealth were not seriously overstated by the methodology.

One point to note about biases in the methodology is that the reclassification of education, primary health care and R&D expenditures from consumption to genuine saving serve to increase the estimated percentage change in total wealth. These adjustments all have the effect of increasing the numerator, genuine savings, while decreasing the denominator, total wealth, in expression (1), and therefore of increasing the likelihood that changes in wealth per capita will be positive.

Another approach to the question of upward bias is to put the total wealth estimate for an individual country, in this case the United States, in context. With an estimate wealth of $462,000 per capita and gross income (GDP) per capita of $29,271, this implies a rate of return on assets of 6.3%, which is not at all out of line with long run real rates of return on assets in the US. Another way to look at this is to note that the present value of this income over 25 years, at a social discount rate of 4%, is $457,000. It seems difficult to argue that the wealth estimate for the US is substantially overstated.

Perhaps the most serious challenge to the results of the wealth estimation arises from Figure 5, which scatters change in wealth per capita against the growth rate in per capita GDP.

Figure 5. Change in wealth per capita vs. GDP per capita growth rate.



The lower right quadrant of this figure highlights the fact that there are a considerable number of countries with positive growth rates in per capita GDP (these are the average rates from 1990-97 shown in Table A1), but declining wealth per capita. Are these findings consistent?

To the extent that growth arises from squeezing more productivity from existing assets, the results are compatible. Productive assets like human capital and buildings and machines have their productivity constrained by bad government policies in many countries. The trend toward liberalization of the economies of developing countries has produced growth, and this liberalization has permitted higher output from existing assets. However, there must be an upward limit on the ability of existing assets to yield greater productivity, which suggests that eventually declines in wealth must produce an impact on output growth.

The other key point to note is that the use of genuine saving in the change in wealth calculation adds an element that is invisible in standard GDP accounts. In particular, GDP as a gross measure counts resource depletion as part of value added. This gives a particularly distorted picture of income in resource-dependent economies where depletion is substantial. So there can be apparent growth in GDP that would not be paralleled in a truer measure of income. In addition, the genuine saving calculation accentuates the low saving rates in many poor countries.

An apparent anomaly in the wealth estimation methodology is that higher levels of consumption translate into higher levels of estimated wealth. It should be recalled, however, that the methodology attempts to estimate a reasonable value for current wealth rather than future wealth. Genuine saving is a better indicator of future wealth. Implicit in the methodology is the

fact that observed consumption per capita embodies a substantial amount of information about the size and productivity of the total capital stock. As regards the question of the share of consumption in national income, it is notable that the countries with the highest consumption share (i.e. the lowest gross savings rate) are predominantly the poorest countries in this analysis.

This issue of the share of consumption in national income does lead to a puzzling result in Table A1. From this table it can be seen that Finland and France have very similar levels of income per capita, nearly identical rates of population growth, and yet France appears to be richer than Finland by $40,000 per capita. The reason for this result, of course, is the higher ratio of consumption to income in France (reflected in the table by a significantly lower genuine saving rate). The 'solution' to this conundrum is to note that Finland is accumulating wealth per capita at a rate that is nearly $1000 per person per year higher than in France – it is building the basis for future wealth and, ultimately, higher levels of consumption derived from this wealth.

The broad conclusion from this analysis is clear from Tables A1 and 2. There is evidence to suggest that, with the notable exception of China, the majority of countries lying below median income per capita are accumulating total wealth – produced assets, infrastructure, natural resources, human capital, social and institutional capital, human health and R&D – at a rate lower than the rate of population growth. While there is ample scope in these countries to achieve higher economic output from existing assets, basically by giving greater scope to markets and developing the institutions that support the operation of markets, this trend in total wealth per capita is ultimately not sustainable.

The wealth estimation methodology presented here could be made considerably less arbitrary if there were (i) widespread data on primary health care expenditures, and (ii) studies on rates of time preference across countries, particularly in developing countries. The other controversial element of the methodology, the 25 year period for present value calculations, could be replaced by something like the average years of remaining life employed in *Expanding the Measure of Wealth*. However, most alternative choices of a period for the estimation would tend to yield values greater than 25 years, inflating the wealth estimate and decreasing the estimated accumulation of wealth per capita.

There is further value to the exercise in this paper, since it gives sharp focus to the question of what is actually consumption, and what is investment. These and similar questions should encourage us to continue to refine our national accounting measures, better adapting them to deal with the challenges inherent in measuring development progress.

Table A1. Change in wealth per capita, by country, 1997.

	GDP / capita $	GDP growth rate 1990-97, %	Population growth rate %	Genuine Saving % of GDP	Wealth / capita $	Change in wealth / capita, $	Change in wealth / capita, %
Algeria	1,606	0.8	2.3	33.9	15,500	185	1.2
Angola	657	-1.2	2.9	8.9	7,400	-153	-2.1
Argentina	9,110	5.4	1.2	12.7	139,800	-499	-0.4
Australia	21,234	3.6	1.0	10.5	319,300	-1,115	-0.3
Austria	25,548	2.0	0.2	17.7	369,900	3,889	1.1
Azerbaijan	579	-15.1	1.0	-25.8	8,600	-234	-2.7
Bangladesh	335	4.7	1.8	11.0	4,500	-43	-1.0
Belarus	2,204	-6.1	-0.1	14.6	27,400	338	1.2
Belgium	23,800	1.4	0.1	19.7	349,600	4,419	1.3
Benin	369	4.5	2.8	11.7	5,200	-103	-2.0
Bolivia	1,027	4.1	2.1	7.5	14,700	-232	-1.6
Botswana	3,307	4.5	2.2	44.2	26,400	892	3.4
Brazil	5,012	3.4	1.4	19.5	70,500	-36	-0.1
Bulgaria	1,213	-3.3	-0.5	12.9	15,900	244	1.5
Burkina Faso	229	3.3	2.4	14.5	3,000	-37	-1.2
Burundi	149	-3.6	2.4	-1.3	2,100	-53	-2.5
Cameroon	654	-0.1	2.6	9.1	8,700	-169	-1.9
Canada	20,066	2.2	0.9	15.6	292,500	587	0.2
Cent African Rep	298	1.2	1.9	11.0	4,100	-48	-1.2
Chad	224	4.6	2.7	-0.8	3,500	-97	-2.8
Chile	5,272	8.3	1.3	19.5	69,300	105	0.2
China	735	11.6	1.0	38.0	6,800	212	3.1
Colombia	2,391	4.4	1.7	14.0	33,200	-230	-0.7
Congo, Dem. Rep.	131	-6.0	3.1	9.6	1,800	-42	-2.3
Congo, Rep.	849	0.7	2.7	15.1	7,700	-79	-1.0
Costa Rica	2,748	3.8	1.9	34.8	32,700	347	1.1
Côte d'Ivoire	721	3.0	2.4	23.4	8,500	-40	-0.5
Czech Republic	5,050	-0.2	-0.1	20.9	60,000	1,097	1.8
Dominican Rep	1,855	5.1	1.7	20.9	24,800	-42	-0.2
Ecuador	1,656	3.1	2.0	9.1	21,900	-277	-1.3
Egypt, Arab Rep.	1,253	4.0	1.9	9.4	17,800	-220	-1.2
El Salvador	1,900	5.6	1.6	3.7	31,100	-433	-1.4
Estonia	3,211	-3.8	-0.4	14.8	43,400	630	1.5
Finland	23,315	1.4	0.3	18.4	318,200	3,299	1.0
France	23,760	1.3	0.3	15.1	359,600	2,394	0.7
Gabon	4,471	3.2	2.5	26.6	37,200	260	0.7
Gambia, The	345	2.2	2.9	0.3	5,000	-145	-2.9
Germany	25,494	1.4	0.1	16.8	375,100	4,025	1.1
Ghana	383	4.2	2.7	6.7	5,600	-125	-2.2
Guatemala	1,690	4.1	2.4	4.9	27,100	-572	-2.1
Guinea	562	5.0	2.4	2.0	7,000	-154	-2.2
Guinea-Bissau	234	3.4	2.0	7.3	3,300	-48	-1.5
Honduras	750	3.3	2.6	23.5	9,200	-64	-0.7
Hungary	4,503	-0.2	-0.3	29.4	54,600	1,491	2.7
India	396	6.0	1.6	12.7	4,800	-27	-0.6
Indonesia	1,073	7.5	1.5	22.1	12,900	42	0.3
Ireland	20,494	7.0	0.5	31.3	254,300	5,027	2.0
Israel	16,806	5.8	1.9	5.0	277,500	-4,476	-1.6
Italy	19,915	1.1	-0.1	16.3	295,800	3,479	1.2
Jamaica	1,619	0.4	1.0	11.3	20,100	-14	-0.1
Japan	33,232	1.5	0.2	24.0	423,400	7,087	1.7
Jordan	1,581	6.3	3.3	4.6	23,800	-707	-3.0
Kenya	358	2.1	2.5	4.4	4,900	-109	-2.2
Korea, Rep.	9,622	7.2	0.9	32.1	113,900	2,091	1.8
Latvia	2,242	-8.5	-0.5	9.6	32,200	369	1.1

	GDP / capita $	GDP growth rate 1990-97, %	Population growth rate %	Genuine Saving % of GDP	Wealth / capita $	Change in wealth / capita, $	Change in wealth / capita, %
Lesotho	472	7.8	2.1	-7.2	8,000	-202	-2.5
Lithuania	2,587	-7.1	0.2	19.1	36,000	433	1.2
Madagascar	251	0.9	2.7	6.8	3,700	-83	-2.2
Malawi	245	3.6	2.6	-0.9	3,600	-96	-2.7
Malaysia	4,545	8.6	2.1	36.3	42,300	749	1.8
Mali	246	3.3	2.7	13.7	3,300	-56	-1.7
Mauritania	446	4.2	2.5	-5.0	6,100	-178	-2.9
Mauritius	3,831	5.0	0.9	22.7	52,100	380	0.7
Mexico	4,271	2.2	1.7	19.3	54,300	-74	-0.1
Mongolia	339	-0.6	2.0	7.8	3,900	-50	-1.3
Morocco	1,227	1.9	1.8	17.5	16,400	-74	-0.4
Mozambique	166	4.9	1.8	15.7	2,100	-12	-0.6
Namibia	2,022	3.8	2.3	8.6	29,000	-492	-1.7
Nepal	221	5.1	2.3	4.5	2,900	-57	-2.0
Netherlands	23,084	2.4	0.4	23.5	313,600	4,258	1.4
New Zealand	17,169	3.4	0.8	19.9	250,800	1,432	0.6
Nicaragua	421	4.1	2.5	8.4	6,100	-116	-1.9
Niger	189	1.5	3.2	6.0	2,700	-76	-2.8
Nigeria	338	2.8	2.7	-10.4	4,300	-152	-3.5
Pakistan	480	4.2	2.4	6.1	6,900	-138	-2.0
Panama	3,032	4.8	1.6	36.9	32,300	600	1.9
Papua New Guinea	1,031	5.7	2.1	19.2	10,200	-12	-0.1
Paraguay	2,002	3.1	2.4	18.9	27,200	-285	-1.0
Peru	2,620	6.2	1.8	21.7	36,300	-82	-0.2
Philippines	1,117	3.3	2.2	8.4	16,200	-258	-1.6
Poland	3,510	4.1	0.3	18.4	47,200	495	1.0
Romania	1,545	-0.3	-0.1	11.5	21,100	198	0.9
Russian Federation	3,034	-7.7	0.0	3.0	38,700	86	0.2
Rwanda	236	-5.7	2.3	-4.4	3,800	-98	-2.6
Saudi Arabia	6,996	1.7	3.8	-10.7	79,800	-3,770	-4.7
Senegal	517	2.5	2.6	17.2	6,800	-86	-1.3
Sierra Leone	173	-4.4	2.1	-9.3	2,800	-74	-2.7
Singapore	31,036	8.5	1.4	41.7	290,900	8,942	3.1
Slovak Republic	3,615	0.6	0.3	23.6	41,300	730	1.8
Slovenia	9,165	1.4	0.1	17.3	122,200	1,487	1.2
South Africa	3,179	1.5	1.7	13.0	41,200	-280	-0.7
Spain	13,530	1.6	0.0	17.3	200,400	2,249	1.1
Sri Lanka	814	5.3	1.2	16.4	11,200	-1	0.0
Sweden	25,724	0.9	0.2	18.8	370,000	4,051	1.1
Syrian Arab Rep	1,202	6.3	2.7	0.5	15,600	-415	-2.7
Tanzania	221	2.7	2.6	9.0	3,100	-61	-2.0
Thailand	2,540	7.4	1.1	30.7	27,100	481	1.8
Togo	339	1.9	2.7	11.8	4,500	-81	-1.8
Trinidad & Tobago	4,507	1.2	1.0	13.4	55,900	48	0.1
Tunisia	2,055	4.3	1.7	22.5	24,700	32	0.1
Turkey	2,979	4.1	1.7	19.3	41,700	-121	-0.3
Uganda	324	7.4	2.5	4.5	4,700	-103	-2.2
Ukraine	980	-13.1	-0.3	3.7	12,500	77	0.6
United Kingdom	21,802	2.0	0.2	11.6	353,000	1,952	0.6
United States	29,271	3.0	0.8	13.2	461,500	322	0.1
Uruguay	6,115	4.0	0.6	12.4	96,000	141	0.1
Venezuela	3,841	2.2	2.0	5.6	47,500	-718	-1.5
Vietnam	324	8.6	1.7	12.4	4,000	-27	-0.7
Zambia	409	1.0	2.4	6.2	5,700	-114	-2.0
Zimbabwe	777	1.8	2.1	7.6	10,100	-153	-1.5

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