

Measuring Sustainable Development: Theory and Application

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Abstract. The paper applies the notion of social well-being to show that “sustainable development” should mean the maintenance of the productive base of an economy relative to its population. It is shown that the concept is operational. Crude data from the world’s poorest countries are used to study whether those countries had experienced sustainable development during the period 1970–2000. The findings are then compared to the experiences of the United Kingdom and the United States.

I. INTRODUCTION

In development economics (in welfare economics, more generally), three questions can be asked in connection with human well-being in an economy: (i) How are people doing? (ii) How have they been doing in recent years? (iii) What should they do? The first question describes the current state of affairs, the second question evaluates recent performance, and the third question seeks to evaluate choices.

No matter which of the three questions we ask, however, we need to have an appropriate measure of human well-being. In recent years, debates on how to measure of human well-being have been influenced by two dichotomies: the constituents versus the determinants of human well-being, and current versus sustainable well-being.¹ In publications from international organizations, much emphasis has been placed on the former dichotomy (e.g., UNDP 1994). It is, however, the case that the most well-known indices of social well-being—gross domestic product (GDP) per capita and the human development index (HDI) of the United Nations Development Programme (UNDP)—are, for all practical purposes, measures of current well-being. Given the attention “sustainable development” continues to receive in international discourse, an index is needed with which to check whether current policies are consistent with sustainable development.

This paper is structured as follows. Section II defines sustainable development while Section III discusses total factor productivity (TFP). The final section, Section IV, discusses the inclusiveness of investments by comparing the

¹The terms “quality of life” and well-being” are used interchangeably in this paper.

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experiences of Pakistan with that of United States (US), People's Republic of China (PRC), and Sub-Saharan Africa. Section V concludes.

II. MEASURING ECONOMIC PERFORMANCE

Table 1, which collates well-known statistics about rich and poor countries, is proto-typical of the way the question, "How are people doing?" is addressed. The table offers no comment on the way the second and third questions may be addressed and answered.

Table 1. **Rich and Poor**

	Rich Nations	Poor Nations
Population (billions)	1.0	2.3
GDP per capita	\$30,000	\$2,100
Human development index	High	low
Annual population growth rate (percent): 1966–2004	0.8	2.4
Annual growth rate of GDP per capita (percent): 1966–2004	2.4	1.8
Total fertility rate	1.8	3.7
Adult literacy (percent)	>95	58
Female literacy (percent)	(>95)	(48)
Index of government corruption	Low	high
Life expectancy at birth (years)	78	58
Under-5 mortality (per 1,000)	7	120
Rural population (percent of total population)	20	70
Agriculture's share in GDP (percent)	5	25

GDP means gross domestic product.

Source: *World Development Indicators* (World Bank 2005).

The right way to judge the economic performance of a country (or for that matter, any economic unit be it household, village, district, state, country, or the world as a whole) is to study movements in its *productive base*. An economy's productive base is composed of its *institutions* and *capital assets*. Institutions are different from capital assets in that the former comprise the social infrastructure (e.g., laws, property rights, beliefs, extent of trust among people) for guiding the allocation of resources, including the capital assets themselves. Capital assets encompass not only manufactured capital (roads, building, machines); human capital (education, skills, and health); and publicly available knowledge (science and technology). It also includes natural capital (minerals, oil, and natural gas; fisheries; forests, soil resources, or more generally, ecosystems).

The social worth of an economy's productive base is considered to be its *inclusive wealth*. In this section, the progress made by the world's poorest regions in recent decades (question ii above) will be examined. Results will confirm that the PRC has performed much better than the other two poor regions of the world, namely, sub-Saharan Africa and the Indian subcontinent. It will also be shown

that the PRC's wealth creation has been far more muted than the expansion of GDP. If degradation of such forms of natural capital as soil and the atmosphere were to be included, the PRC's wealth creation would probably seem even more muted.

A. Definition of Sustainable Development

Following the Brundtland Commission Report (World Commission on Environment and Development 1987), I adopt the view here that "sustainable development" means *sustained* social well-being, and that well-being means not just current well-being, but well-being across generations. The index of social well-being I shall work with is the present value of the flow of each generation's well-being. This is of course a familiar concept in development economics. It was adopted long ago in the theory and empirics of national saving rates and has been the foundation of the theory and empirics of social cost benefit analysis. Hence, "*sustainable development*" is an economic programme along which average well-being of present and future generations, taken together, does not decline over time.

B. Sustainable Development and Inclusive Investment

It can be shown that an economy enjoys sustainable development if and only if, relative to its population, its inclusive wealth (at constant prices) does not decline.² Naturally, a change in inclusive wealth over time (at constant prices) is *inclusive investment*. An economy would enjoy sustainable development if and only if, relative to its population, inclusive investment is not negative.³ This is the sense in which inclusive wealth is a measure of intergenerational well-being. It is also the sense in which accumulation of wealth corresponds to sustained development. Inclusive investment is thus a key to economic progress.

A capital asset's worth is its quantity multiplied by the present value of the flow of social benefits an extra unit would be able to generate over time. That present value is called the asset's *shadow price*. Hence, an economy's inclusive wealth is the shadow value of its productive base, and inclusive investment is the shadow value of the net change in its productive base. Of course, even if some assets have decumulated, inclusive wealth would increase if there were compensatory accumulation of other assets in the economy. Similarly, even if

²See Dasgupta and Mäler (2000) for the case of constant population, and Dasgupta (2001) and Arrow et al. (2003a and b) for the case of variable population.

³Those familiar with the Brundtland Commission Report will recognize this as a precise formulation of its definition of sustainable development, namely, "... development that meets the needs of the present without compromising the ability of future generations to meet their own needs." In this reckoning sustainable development requires that relative to their populations each generation should bequeath to its successor at least as large a productive base as it had itself inherited. Notice that the requirement is derived from a relatively weak notion of intergenerational justice. Sustainable development demands that future generations have no less of the means to meet their needs than the present has.

some assets have accumulated (building, roads, machines), inclusive wealth would decline if there was a substantial decumulation of other forms of capital assets (wetlands, coastal waters, forests, the atmosphere as a sink for pollutants).

Inclusive investment is to be contrasted from recorded investment. Because a wide range of services obtained from natural capital are missing from standard economic accounts, recorded investment could be positive even if inclusive investment was negative—a possibility explored in Table 2. On the other hand, current accounting practice does not recognize that nutrition, health care, and potable water are not merely consumption goods, but they are simultaneously investment goods. Thus, there is corresponding undercounting in recorded investment.

Table 2. **The Progress of Nations**

Country/Region	Annual Growth Rate, 1970–2000 (percent)					
	I/Y*	Population	TFP**	Productive Base	GDP	Δ HDI***
	(percentage)	(per head)		(per head)	(per head)	
Sub-Saharan Africa	-2.1	2.7	0.1	-2.9	-0.1	+
Bangladesh	7.1	2.2	0.7	0.1	1.9	+
India	9.5	2.0	0.6	0.4	3.0	+
Nepal	13.3	2.2	0.5	0.6	1.9	+
Pakistan	8.8	2.7	0.4	-0.7	2.2	+
People's Republic of China	22.7	1.4	3.6	7.8	7.8	+
United Kingdom	7.4	0.2	0.7	2.4	2.2	+
United States	8.9	1.1	0.2	1.0	2.0	+

* means inclusive investment as a share of GDP (average over 1970–2000).

** means total factor productivity.

*** means change in HDI between 1970 and 2000.

GDP means gross domestic product.

Source: Adapted from Arrow et al. (2004).

The notion of investment I am advocating here is not only inclusive of various types of capital assets, it also inclusive of individual and locational differences. A pond in one location is a different asset from a pond in another, because their ecological characteristics are likely to differ, and because the communities making use of them are likely to face different economic circumstances. It follows that seemingly identical ponds should have different shadow prices. Of course, in practice, such refinements may not be attainable. But it is always salutary to be reminded that macroeconomic reasoning glosses over the heterogeneity of the earth's resources, and the diverse ways to which they are put to use by people residing at the site and elsewhere. Shadow prices depend not only technology and consumer preferences, but also on institutions and their combined effect on people's lives.

C. Substitution Possibilities and Sustainable Development

It is important to realize that even if an economy satisfies the sustainability criterion (i.e., relative to population, inclusive investment is not negative) today, or has satisfied the criterion in the recent past, it might not continue to do so in the future. Whether it is able to do so depends on the scale of the economy (measured by, say, gross domestic product [GDP]), among other things. If the scale becomes too large relative to the natural capital base of the economy, the economy will be unable to maintain its inclusive wealth. Specifically, as an economy's scale increases, natural capital (e.g., ecosystems) becomes more scarce relative to the size of the economy. Consequently, the amount of other types of capital needed to substitute for natural capital—that is, the shadow price of natural capital—may rise. The extent to which the shadow price rises depends on a number of factors, including the rate of technological progress. There can even come a point where no amount of feasible investment in manufactured capital or human capital can offset further declines in natural capital (Ehrlich and Goulder 2007).

D. Weaknesses in GDP and HDI

It is easy to see why GDP is inadequate as an index of sustainable development. An economy's productive base will shrink if its stock of capital assets depreciates, and its institutions are not able to improve sufficiently to compensate for that depreciation. The term GDP is an acronym for *gross* domestic product. The word "gross" means that GDP ignores the depreciation of capital assets. It is certainly possible for a country's productive base to grow while its GDP increases (this is confirmed in Table 2), which is no doubt a path of economic development we all would like to follow. However, it is also possible for a country's productive base to *shrink* during a period when GDP grows (this is also confirmed in Table 2). The problem is that no one would notice the shrinking if everyone's eyes were riveted on gross domestic product. If the productive base continues to shrink, economic growth will, sooner or later, stop and reverse sign. The standard of living will then decline, but no one would have suspected that a fall was forthcoming. Thus, growth in GDP per head can encourage us to think that all is well when in fact it is not. Similarly, it is possible for a country's HDI to increase even while its productive base shrinks. This means that HDI too can mislead.

The moral is telling: GDP (or for that matter, HDI) is not a measure of long-run human well-being, and that movements in GDP or HDI are a poor basis for judging economic progress.

In advocating HDI over GDP, the UNDP (1994, 14–15) castigated those who regard GDP to be an index of an economy's well-being on the grounds that it is a measure of a country's "opulence." The criticism is faulty in two ways. Firstly, opulence is a stock concept, and GDP is not a return on any index of

opulence that I am aware of.⁴ Secondly, and more importantly, as we have just noted, it is not a mistake to seek to measure a society's well-being in terms of an index of opulence. The point is not that opulence misleads, but rather, we should search for the *right measure* of opulence.

III. INSTITUTIONS: WHAT ABOUT THE RESIDUAL?

The aggregate output of an economy is produced by various factors of production. We can therefore decompose observed changes in output over time into its sources: how much can be attributed to changes in labor force participation, how much to accumulation of manufactured capital and human capital, how much to the accumulation of knowledge brought about by expenditure in research and development, how much to changes in the use of natural resources, and so on. If a portion of the observed change in output cannot be credited to any of the above factors of production, that portion is called the change in total factor productivity. Growth in TFP is known as the *residual*, to indicate that it is that bit of growth in output that cannot be explained.

Should wealth decline, could growth in TFP not compensate for the decline and ensure that long-run well-being is sustained? Traditionally, labor force participation, manufactured capital, and marketed natural resources have been the recorded factors of production. In recent years, partial measures of human capital have been added. Attempts have also been made also to correct for changes in the quality of manufactured capital brought about by research and development. But national accounts mostly still do not include the use of nonmarketed natural resources—nor, for that matter, nonmarketed labor effort—for the understandable reason that shadow prices of nonmarketed natural resources are extremely hard to estimate. Moreover, how do you estimate unrecorded labor effort? Now imagine that over a period of time the economy makes increasing use of the natural resource base, or of unrecorded labor effort. The residual would be overestimated. In fact, a simple way to increase the residual would be to “mine” the natural resource base at an increasing rate. But this would be a perverse thing to do if we seek to measure economic prospects.

What if it is possible to decompose the growth of an economy's aggregate output in a comprehensive manner, by tracing the growth to the sources originating from all the factors of production? To assume that over the long run the residual could still be positive is to imagine that the country enjoys a “free lunch” (like manna from heaven). Is the latter a possibility? One way to enjoy a free lunch, for poor countries at least, is to use technological advances made in other countries without paying for them. The residual would then reflect increases in freely available knowledge. Note though that adaptation is not without cost. To meet local conditions, adjustments need to be made to product design and to the

⁴One can even argue that, because it does not take note of capital depreciation, GDP cannot be a measure of opulence. It can also be shown that *net* national product also would not work as an index of sustainable development (see Dasgupta 2001).

processes involved in production, all of which require appropriate local institutions that are frequently missing in poor countries.

Of course, TFP can have short bursts. Imagine that a government reduces economic inefficiencies by improving the enforcement of property rights, or by reducing centralized regulations (import quotas, price controls, and so forth). We would expect the factors of production to find better uses. As factors realign in more productive fashions, TFP would increase.

In the opposite vein, TFP could decline over a period. Increased government corruption or civil strife could cause this decline, which not only destroys capital assets, but also damages a country's institutions, both public or civic. When institutions deteriorate, assets are used even more inefficiently than previously, and TFP declines.

IV. WEALTH MOVEMENTS IN POOR COUNTRIES: HAS ECONOMIC DEVELOPMENT IN RECENT DECADES BEEN SUSTAINABLE?

Economists at the World Bank (Hamilton and Clemens 1999) have estimated inclusive investment in different countries during the past few decades. They have done that by adding net investment in human capital to existing countrywide estimates of investment in manufactured capital, and then subtracting *disinvestments* in natural capital from that sum. The economists used official estimates of net national saving as proxies for net investment in manufactured capital. For estimates of investment in human capital, they used expenditure on education as a proxy.⁵ To quantify disinvestments in natural capital, they considered net changes in the stocks of commercial forests, oil and minerals, and quality of the atmosphere in terms of its carbon dioxide content. Oil and minerals were valued at their market prices minus extraction costs. The shadow price of global carbon emission into the atmosphere is the damage caused by bringing about climate change. That damage was taken to be \$20 per ton, which in all probability is a serious underestimate. Forests were valued in terms of their market price minus logging costs. Contributions of forests to ecosystem functions were ignored.

The World Bank's list of natural resources is incomplete. It does not include water resources, fisheries, air and water pollutants, soil, and ecosystems. Their notion of human capital is inadequate because health does not enter the calculus. And their estimates of shadow prices are just approximate. Nevertheless, one has to start somewhere, and the World Bank's is a first pass at what is an enormously messy enterprise.

What I want to do now is to examine figures published recently by a group of ecologists and economists (Arrow et al. 2004), who adapted the World Bank estimates of inclusive investment, and then went on to determine whether economic development in some of the major countries and regions has been

⁵In recent work, Arrow et al. (2007) have greatly refined the way human capital is measured.

sustainable in recent decades. Table 2 is a refinement of that study. It remains a crude beginning to the study of sustainable development, but is a start.

The places in question are sub-Saharan Africa, Bangladesh, India, Nepal, and Pakistan (all poor countries); PRC (a middle-income country); and United Kingdom and United States (both rich countries). The period under study is 1970–2000. The first column in Table 2 consists of refinements of the World Bank’s estimates of average inclusive investment as a proportion of gross domestic product. The second column gives the average annual population growth rate. The third column gives estimates of annual growth rates of TFP, which we take as the annual percentage rate of change in a combined index of knowledge and institutions. The figures in the first three columns are used to arrive at estimates of the annual percentage rate of change in the productive base per capita. They are given in the fourth column.

Before summarizing the findings, it will be useful to get a feel for what the numbers in the table are telling us. Consider Pakistan. During 1970–2000, inclusive investment as a proportion of GDP was 8.8 percent annually. Total factor productivity increased at an annual rate of 0.4 percent. As both figures are positive, we can conclude that Pakistan’s productive base was larger in year 2000 than it had been in 1970. But looking at Pakistan’s population, which grew at a high 2.7 percent rate annually, the fourth column shows that Pakistan’s productive base per capita consequently declined at an annual rate of 0.7 percent, implying that in year 2000 it was about 80 percent of what it was in 1970.

In contrast, consider the United States. Inclusive investment as a share of GDP was 8.9 percent a year, which is only slightly larger than that of Pakistan. Growth in TFP (an annual 0.2 percent) was even lower than Pakistan’s. But population grew only at 1.1 percent a year, meaning that the productive base per capita in the US grew at an average annual rate of 1 percent. Economic development in the US was sustainable during 1970–2000, while in Pakistan it was unsustainable.

Interestingly, judging economic performance in terms of growth in GDP per capita gives a different picture. As the fifth column of Table 2 shows, Pakistan grew at a respectable 2.2 percent rate a year, while the US grew at only 1.1 percent a year. The HDI for Pakistan improved during the period, although the movements in HDI tell us nothing about sustainable development.

The striking message in Table 2, however, is that during 1970–2000 economic development in *all* the poor countries on the list was either unsustainable or barely sustainable. Sub-Saharan Africa offers no surprise. Its inclusive investment was negative, implying that the region *disinvested* in manufactured, human, and natural capital—altogether at 2.1 percent of gross domestic product. Population grew at 2.7 percent a year and TFP barely advanced (annual growth rate was only 0.1 percent). Even without performing any calculation, we should suspect that the productive base per capita in sub-Saharan Africa declined. Table 2 confirms that it did, at 2.9 percent annually.

Looking further at the values, GDP per capita in sub-Saharan Africa remained fairly constant. But the region’s HDI showed an improvement,

confirming once again that studying movements in HDI enables us to say nothing about sustainable development.

Pakistan is the worst performer in the Indian subcontinent, but the remaining countries in the region just barely made it when judged in terms of sustainable development. Inclusive investment in each country (Bangladesh, India, and Nepal) was positive, as was growth in total factor productivity. The two together imply that the productive base expanded in each country. But population growth was so high that the productive base per capita just about grew at annual percentage rates 0.1, 0.4, and 0.6 respectively. Even these figures are most likely to be overestimates. The list of items that Hamilton and Clemens (1999) used in order to estimate inclusive investment did not include soil erosion and urban pollution, both of which are considered by experts to be problematic in the Indian subcontinent. Moreover, the human desire to reduce risk, mentioned earlier, implies that downside risks of natural capital degradation should be given a higher weight than a corresponding chance that things will turn out to be better than expected. Thus, allowing for risk aversion, estimates of inclusive investment would be lowered. One cannot help suspecting that economic development in the Indian subcontinent was unsustainable during 1970–2000. But one would not discern that from figures for GDP per capita and the human development index. The former grew in each country in the region and the latter improved.

Meanwhile, in the PRC, inclusive investment was 22.7 percent of GDP, a very large figure in the sample of countries in Table 2. Growth in TFP was a high 3.6 percent while population had grown at a relatively low 1.4 percent annual rate. We should not be surprised that the PRC's productive base per capita expanded—as it happens, at 7.8 percent annually. Per capita GDP also grew at an annual rate of 7.8 percent, and HDI improved. In the PRC, GDP per capita, HDI, and the productive base per head moved in parallel.

There is little to comment on the United Kingdom and the United States. Both are rich, mature economies. Inclusive investment during 1970–2000 was modest, but then so was population growth. Growth in TFP was low. Although the figures imply that the productive base per capita expanded in both countries, we should be circumspect because, as noted earlier, the World Bank costed carbon emissions at too low a rate. Gross domestic product per capita increased in both countries, and HDI improved.

V. CONCLUSION

The figures just presented are preliminary, but they show how accounting for natural capital can make a substantial difference in the conception of the development process. In Table 2, I have deliberately made conservative assumptions regarding the degradation of natural capital. For example, a price of \$20 per ton of carbon in the atmosphere is almost certainly a good deal below its true social cost (or negative shadow price). Taking instead the reasonable shadow price of \$75 per ton, all the poor countries in Table 2 would show a decline in their GDP per capita during 1970–2000.

The message we should take away is sobering. Over the past three decades, sub-Saharan Africa (home to 750 million people today) has become poorer if judged in terms of its productive base per capita. Economic development in the Indian subcontinent (home to over 1.4 billion people today) was either unsustainable or just barely sustainable. That said, it would be wrong to conclude that people in poor countries should have invested more in their productive base by consuming less. The production and distribution of goods and services in poor countries are highly inefficient. It would be wrong to regard consumption and investment in the productive base there as competing for a fixed quantity of funds. Rather, the creation of better institutions to enable people in the world's poorest regions to both consume more and invest more (inclusively, of course!) is the first step toward achieving sustainable development.

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