PART 2

CHANGES IN WEALTH

Chapter 3

Recent Genuine Saving Estimates

However sustainable development is defined,[1] achieving it is, at heart, the process of maintaining wealth for future generations. Wealth is conceived broadly to include not only the traditional measures of capital, such as produced and human capital, but also natural assets. Natural capital comprises assets such as land, forests, and subsoil resources. All three types of capital—produced, human, and natural—are key inputs to sustaining economic growth.

The standard national accounts measure the change in a country's wealth by focusing solely on produced assets. A country's provision for the future is measured by its gross national saving, which represents the total amount of produced output that is not consumed. Gross national saving, however, can say little about sustainable development, since assets depreciate over time. Net national saving equals gross national saving minus depreciation of fixed capital and is one step closer to measuring sustainability. The next step in measuring sustainability is to adjust net saving for the accumulation of other assets—human capital, the environment, and natural resources—that underpin development.

This chapter introduces the concept of *genuine* saving (formally known as adjusted net saving) first derived in Pearce and Atkinson (1993) and Hamilton (1994). It then presents and discusses the empirical calculations of genuine saving rates available for over 140 countries (tabulated in appendix 3). Genuine saving provides a much broader indicator of sustainability by valuing changes in natural resources, environmental quality, and human capital, in addition to the traditional measure of changes in produced assets provided by net saving.

Negative genuine saving rates imply that total wealth is in decline; policies leading to persistently negative genuine saving are unsustainable. In addition to serving as an indicator of sustainability, genuine saving has the advantage of presenting resource and environmental issues within a framework that finance and development planning ministries can understand. It makes the growth-environment trade-off explicit, since those countries pursuing economic growth today, at the expense of natural resources, will be notable by their depressed rates of genuine saving. Of the 140 countries where genuine saving is estimated for 2003, just over 30 have negative saving rates.

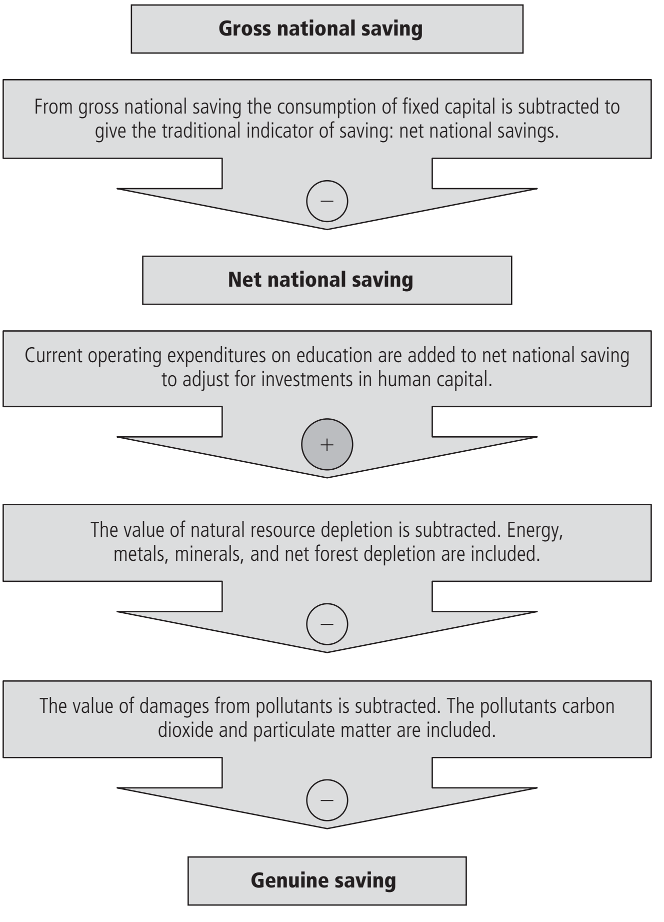
Calculating Genuine Saving

Figure 3.1 provides a flow chart describing each of the main steps in the genuine saving calculation. Starting at the top of figure 3.1, the calculation of genuine saving begins with gross national saving. Gross national saving is calculated as the difference between the gross national income (GNI) and public and private consumption plus net current transfers. From this the consumption of fixed capital is subtracted, giving the traditional measure of net national saving. Consumption of fixed capital represents the replacement value of capital used up in the process of production.

In the traditional measure of net national saving only that portion of total expenditure on education that goes toward fixed capital (such as school buildings) is included as a part of saving; the rest is treated as consumption. From the perspective of broadening the measure of wealth this is clearly unsatisfactory. Therefore, as a crude approximation, current operating expenditures on education, including wages and salaries and excluding capital investments in buildings and equipment, are added to net national saving.[2]

Natural resource depletion is then subtracted. The value of resource depletion is calculated as the total rents on resource extraction and harvest, where rents are estimated as the difference between the value of production at world prices and total costs of production, including depreciation of fixed capital and return on capital. The energy resources include oil, natural gas, and coal, while metals and minerals include bauxite, copper, gold, iron ore, lead, nickel, phosphate, silver, tin, and zinc.

Figure 3.1 Flow Chart of Genuine Saving Calculation



As a living resource, forest resources are fundamentally different from energy, metals, and minerals. The correction to the net saving rate is thus not simply rent on timber extraction, but rather rent on that portion of timber extraction that exceeds natural growth. If growth exceeds harvest, this figure is set to zero.

The genuine saving calculation also includes the value of damages from air pollution. Pollution damages can enter the national accounts in several ways. While, in theory, pollution damage to produced assets is included in depreciation figures, in practice, most statistical systems are not detailed enough to capture this. For example, acid rain damages to building materials are rarely fully accounted. The effects of pollution on output—damage to crops, for example—are already included in the standard national accounts, although not explicitly.

Next is the adjustment for damages from carbon dioxide, using a figure for marginal global damages of $20 (1995 prices) per metric ton of carbon emitted (Fankhauser 1994).[3] This represents the present value of marginal damages to crops, infrastructure, and human health over the time that emitted carbon dioxide resides in the atmosphere—over 100 years.

Finally, the value of health damages arising from particulate matter pollution is deducted. Particulate air pollution is capable of penetrating deep into the respiratory tract and causing damage, including premature mortality. The population-weighted average level of PM_{10} (particulate matter less than 10 microns in diameter) is estimated for all cities in each country with a population in excess of 100,000. Particulate emission damage is calculated as the willingness to pay to reduce the risk of mortality attributable to PM_{10} (Pandey and others 2005).

The net result of all these adjustments is genuine saving.

Interpreting Genuine Saving Estimates

Welfare can be sustained indefinitely if gross saving just equals the sum of depreciation of produced assets, depletion of natural resources, and pollution damages. This is the well-known Hartwick rule. A persistently negative genuine saving rate implies that a country is on an unsustainable path and welfare must fall in the future.

However, we should be cautious in interpreting a positive genuine saving rate. There are some important assets omitted from the analysis for methodological and empirical reasons, which may mean that saving rates are only apparently positive. First, fisheries can be a significant resource for a local or national economy. However, it can be very difficult to measure fish stocks and to attribute ownership to one country, not least because of their mobility. Soil erosion is another important issue, especially in agrarian economies. Attaching a value to soil erosion requires detailed local data that are not widely available, and it can be extremely difficult to disentangle the economic costs of soil erosion from the physical losses (see box 3.1). Diamonds are another important resource for some countries, most significantly in Angola, Botswana, the Democratic Republic of Congo, Namibia, the Russian Federation, and

South Africa. Diamonds are excluded from the analysis because of data availability issues and the lack of free-market prices.

Box 3.1 Soil Degradation and Changes in Wealth

Ideally, adjusted net or genuine saving should include the depletion and degradation of land resources, which contribute 18 percent of total wealth in low-income countries. However, data comparability and availability do not allow for systematic inclusion of this item in the saving analysis.

For many low-income countries that depend on the natural resource base for their development, the loss of soil quality can be a major problem. The UN Convention to Combat Desertification is a policy response to this trend, and the recently published *Millennium Ecosystem Assessment* (2005) points to land degradation in drylands, in particular in Africa and Central Asia, as one of the major challenges now facing the international community. Many of the poorest countries in the world face serious land degradation problems.

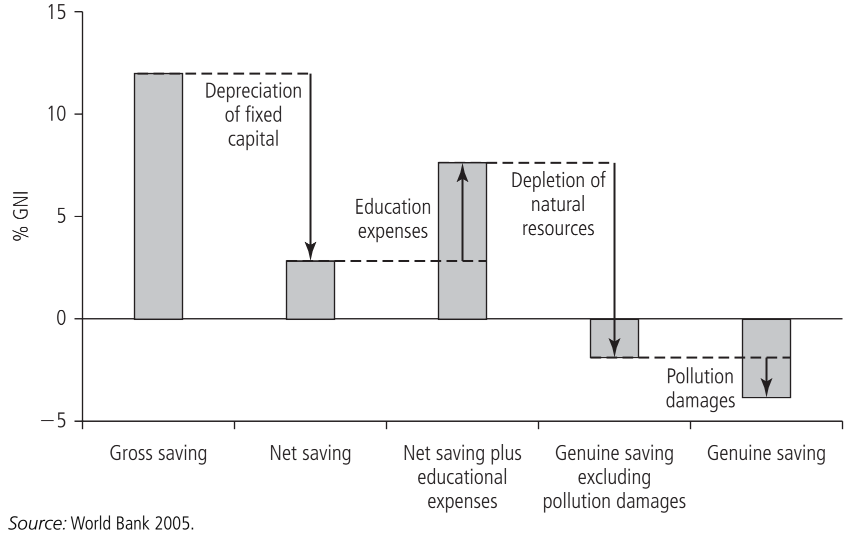
Statistical information on the cost of land degradation is not widely available, largely because the effects of erosion are complex to measure with accuracy. It is not sufficient to measure on-farm effects since the external consequences of erosion can be significant. Negative off-farm effects of erosion include siltation of dams, salinization, and loss of biodiversity. But there are also positive effects of erosion—for example, delta landscapes, such as the Nile Delta and Bangladesh, depend on the yearly deposit of soil and nutrients transported by rivers for their fertility.

It is probably safe to assume that soil erosion that goes considerably beyond natural levels has negative economic effects. Through case studies undertaken for seven developing countries in Africa, Asia, and Latin America it has been estimated that the problems of sustainable land management deduct 3 percent to 7 percent from agricultural GDP (Berry and others 2003). A study from Australia (Gretton and Salma 1996) estimates soil fertility loss equivalent to 6 percent of agricultural production. Soil losses can be significant.

The Genuine Saving Calculation: A Country Example

Figure 3.2 shows the steps in calculating genuine saving for Bolivia, one of the poorest countries in Latin America, with GDP per capita below $1,000. Bolivia is endowed with a wealth of natural resources, including minerals, oil, and huge deposits of natural gas discovered at the end of the 1990s.

Figure 3.2 Adjustments in the Genuine Saving Calculation for Bolivia (2003)



Source: World Bank 2005.

The first column in figure 3.2 shows the traditional measure of gross national saving in Bolivia, 12 percent of gross national income (GNI) in 2003. Deducting the depreciation of produced capital reveals a much lower net saving rate, less than 3 percent. Investments in education are estimated to be around 5 percent of GNI, bringing the saving rate up to nearly 8 percent as shown by the third column in figure 3.2.

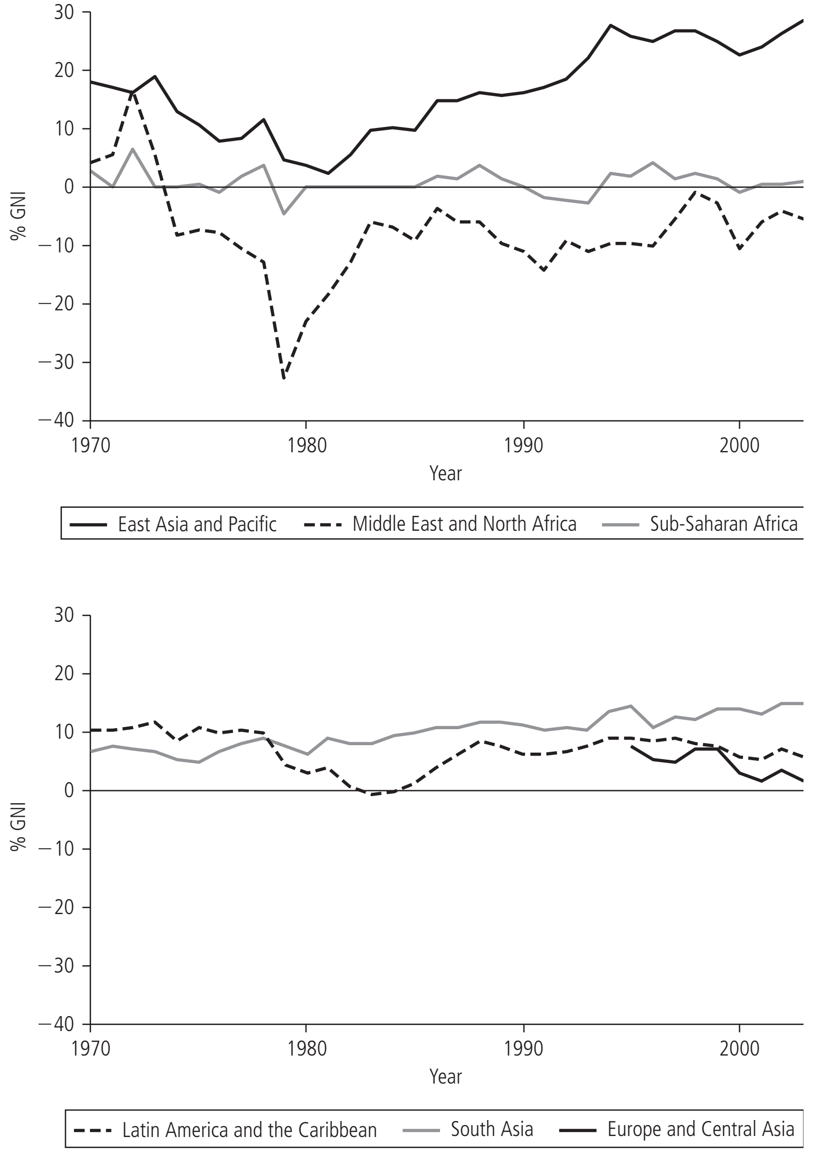
Following this, adjustments are made for depletion of natural resources. Resource rents from Bolivia's extraction of oil and gas are deducted, as well as the rents from gold, silver, lead, zinc, and tin. Depletion of energy, metals, and minerals amount to over 9 percent of the GNI. While deforestation is deemed to be a problem in Bolivia, available data suggest that net forest depletion is zero. As a result of these deductions for resource depletion, Bolivia's genuine saving rate is negative.

Finally, the deduction for pollution damages leads to a bottom-line estimate of Bolivia's genuine saving rate of minus 3.8 percent of GNI. Bolivia is currently on an unsustainable development path.

Regional Disparities

The calculation of aggregate genuine saving rates by region reveals some striking differences between regions of the world as shown

Figure 3.3 Genuine Saving Rates by Region



Source: World Bank 2005.

in figure 3.3. The Middle East and North Africa stands out for its consistently negative saving rate, reflecting high dependence on petroleum extraction. However, not all countries in the region have negative genuine saving rates. Jordan, Morocco, and Tunisia had consistently positive genuine saving rates over the period, exceeding 15 percent of GNI.

Regional genuine saving rates are highly sensitive to changes in world oil prices. The Iranian revolution from 1978 to 1979 followed by the Iran-Iraq war in 1980 resulted in crude oil prices more than doubling from $14 in 1978 to $35 per barrel in 1981. This is clearly shown in figure 3.3—genuine saving rates dipped in the region, largely owing to the consumption of sharply increased oil rents.

In stark contrast to the Middle East and North Africa stands the East Asia and Pacific region, with recent aggregate genuine saving figures nearing 30 percent, driven largely by China. This diverse region has enjoyed steady economic growth and progress toward poverty reduction. From 1999 to 2004, the number of East Asians living on less than $2 a day fell from 50 to 34 percent, or by about 250 million people. The boom in economic performance from the second half of the 1980s until the Asian financial crisis in 1997 is reflected in the genuine saving numbers, largely driven by increases in gross national saving.

In Sub-Saharan Africa, the poorest region in the world, the number of people living in extreme poverty has almost doubled, from 164 million in 1981 to 314 million today. Genuine saving rates in the region have been hovering around zero. The aggregation masks wide disparities between countries in the region. Positive genuine saving rates in countries such as Kenya, Tanzania, and South Africa are offset by strongly negative genuine saving rates in resource-dependent countries such as Nigeria and Angola, which have genuine saving rates of minus 30 percent.

South Asia displays consistently strong genuine saving rates. The regional aggregate genuine saving rate has been fluctuating between 10 and 15 percent since 1985, with India dominating the aggregate figure. Nepal is the region's new strong saver with genuine saving rates reaching nearly 30 percent in 2003. Nepal's gross national saving rate has been steadily increasing from the 1990s to the present day.

Latin American genuine saving rates have remained fairly constant throughout the 1990s. The large economies in the region, Mexico and Brazil, have positive genuine saving rates in excess of 5 percent. However, for the region's largest oil producer, República Bolivariana de Venezuela, saving rates tell a different story. Like many other oil producers, República Bolivariana de Venezuela's genuine saving rate has been persistently negative since the late 1970s.

Regional genuine saving data for Eastern Europe and Central Asia are only available from 1995. Saving rates have fallen from over

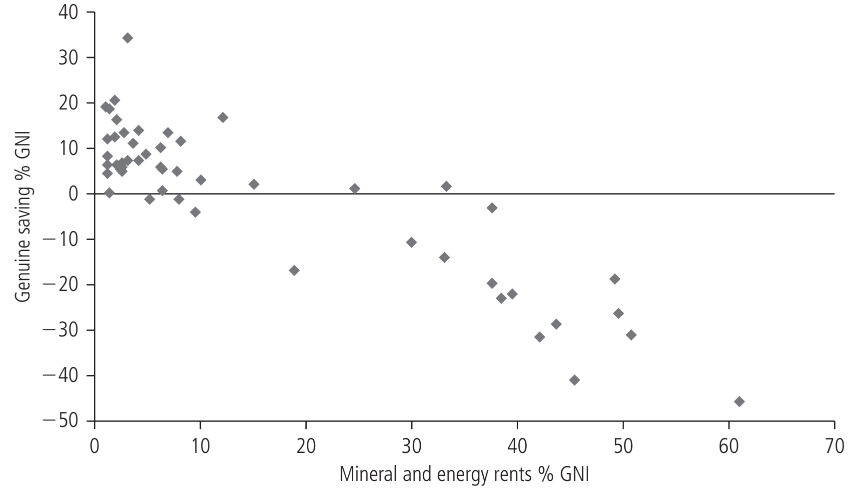
7.7 percent in 1995 to 1.7 percent in 2003. Of the 23 countries for which data were available in the region, 17 have positive genuine saving rates in 2003, averaging around 10 percent of GNI. However, the oil states of Azerbaijan, Kazakhstan, Uzbekistan, Turkmenistan, and the Russian Federation all have persistently negative genuine saving rates, thus pulling the regional aggregate downwards.

Consuming Resource Rents

Stocks of exhaustible resources such as oil represent a potential source of development finance. The question for countries with resource endowments is whether to consume these resource rents, providing current welfare but at a cost to future generations, or to invest the rents in other assets. Figure 3.4 scatters genuine saving rates against mineral and energy rents for resource-rich countries (defined as countries with exhaustible resource shares in excess of 1 percent of GNI).

Figure 3.4 shows that as resource rents increase as a percentage of GNI, genuine saving rates tend to decline. This implies that a significant proportion of natural resource rents are being consumed rather than

Figure 3.4 Genuine Saving and Exhaustible Resource Share (share 2003)



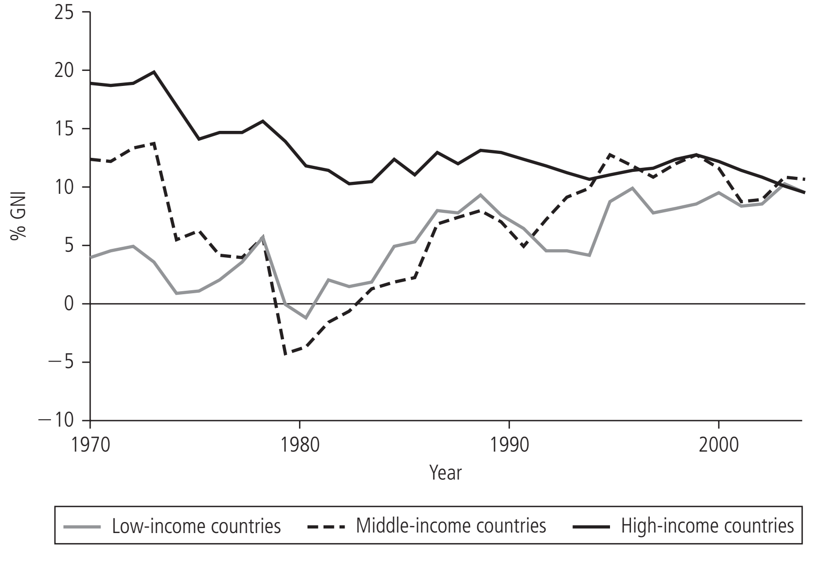
Source: World Bank 2005.

invested in other productive assets. Chapter 4 explores this issue further and finds that the consumption rather than investment of resource rents is common in resource-rich countries.

Income and Saving

Genuine saving estimates for the 1970s reveal a worrying trend: rich countries had considerably higher saving rates than poorer countries, implying a potentially wider divergence in income and wealth between high-income and low-income countries. In 1970, high-income countries were saving 15 percent more of their GNI than low-income countries. Genuine saving rates for low-income countries were positive in aggregate, but only equal to 4 percent of GNI. However, as shown in figure 3.5, genuine saving rates have converged over time. In fact, in 2003 high-income countries were saving less as a percentage of GNI than both low- and middle-income countries. High-income countries saving rates as a percentage of GNI have declined over time, while saving rates for low- and middle-income countries have increased.

Figure 3.5 Genuine Saving Rates by Income Group



Source: World Bank 2005.

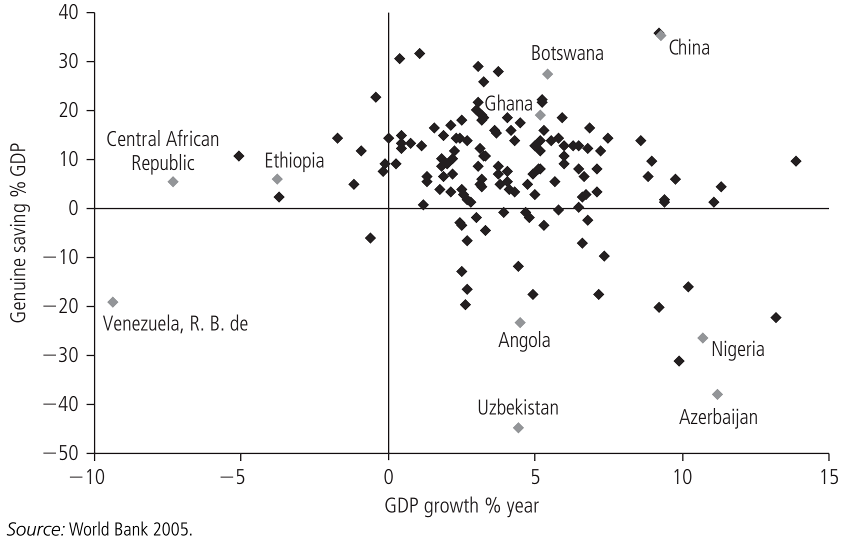
Saving and Growth

Figure 3.6 scatters genuine saving rates (as percentage of GDP) against GDP growth in 2003. Countries in the top-right quadrant have positive GDP growth rates and positive genuine saving rates. These economies are growing and, according to the genuine saving measure, not at the expense of future generations. This points to a positive future for countries like Botswana, China, and Ghana, all of whom have strong economic growth and positive genuine saving rates.

Countries in the top-left-hand quadrant of figure 3.6 are experiencing contracting economies with declining GDP. However, these countries have positive genuine saving rates, implying they are still investing for the future.

Traditional indicators of economic growth would suggest that those countries in the bottom-right-hand corner of figure 3.6 are doing well—economic growth is positive. However, when genuine saving is taken into consideration, this optimistic story changes. Countries such as Nigeria, Angola, Uzbekistan, and Azerbaijan all have growing economies, but negative genuine saving rates may be imperiling future generations.

Figure 3.6 Genuine Saving Rates against Economic Growth (2003)



Source: World Bank 2005.

Countries in the bottom-left-hand quadrant face the biggest challenge. These economies are currently shrinking, while at the same time future welfare prospects are being reduced as a result of negative genuine saving rates. República Bolivariana de Venezuela is a case in point—persistent negative levels of economic growth[4] and genuine saving paint a troubling picture for future welfare.

Conclusions

Genuine saving provides an indicator of sustainability. There are many countries for which negative genuine saving rates are a reality (see appendix 3). In addition, those countries with low positive levels of genuine saving may also be pursuing a policy mix that will result in declining welfare over time, since measures of the depreciation of key assets may be masked by lack of data and methodological limitations.

Genuine saving rates differ widely throughout the world as shown by the regional aggregates in figure 3.3. The evidence suggests that while resource-rich countries have the potential to achieve sustainable development if resource rents are appropriately invested, many are not doing so, as shown in figure 3.4.

Genuine saving is useful to policy makers not only as an indicator of sustainability, but as a means of presenting resource and environmental issues within a framework familiar to finance and development planning ministries. It underlines the need to boost domestic saving, and hence, the need for sound macroeconomic policies, and it highlights the fiscal aspects of environment and resource management, since collecting resource royalties and charging pollution taxes are basic ways to both raise development finance and ensure efficient use of the environment.

Endnotes

1. See Pearce (1993) for a discussion on the definition of sustainable development.

2. For a further discussion of accounting for human capital in the genuine saving calculation see World Bank (1996).

3. Tol (2005) reviewed over 100 estimates of the marginal damage cost of carbon dioxide emissions. He found a large range of uncertainty: the median cost was found to be $14 per ton of carbon and the mean to be $93/tC. On balance the use of the Fankhauser (1994) estimate of $20/tC appears to be reasonable.

4. República Bolivariana de Venezuela GDP has declined by 11 percent between 1993 and 2003.

Chapter 4

THE IMPORTANCE OF INVESTING RESOURCE RENTS: A HARTWICK RULE COUNTERFACTUAL

A substantial empirical literature documents the *resource curse* or *paradox of plenty*.[1] Resource-rich countries should enjoy an advantage in the development process, and yet these countries experienced lower GDP growth rates post-1970 than less well-endowed countries. A number of plausible explanations for this phenomenon have been suggested:

- Inflated currencies may impede the development of the nonoil export sector (this is known as "Dutch disease").
- Easy money in the form of resource rents may reduce incentives to implement needed economic reforms.
- Volatile resource prices may complicate macroeconomic management, exacerbating political conflicts over the sharing and management of resource revenues.

In the most extreme examples, levels of welfare in resource-rich countries are lower today than they were in 1970—development has not been sustained. The Hartwick rule (Hartwick 1977; Solow 1986) offers a rule-of-thumb for sustainability in exhaustible-resource economies—a constant level of consumption can be sustained if the value of investment equals the value of rents on extracted resources at each point in time. For countries dependent on such wasting assets, this rule offers a prescription for sustainable development, a prescription that Botswana, in particular, has followed with its diamond wealth (Lange and Wright 2004).

Drawing on a 30-year time series of resource rent data underlying chapter 3, this chapter constructs a Hartwick rule counterfactual: how rich would countries be in the year 2000 if they had followed the Hartwick rule since 1970? The empirical estimations below test two variants of the Hartwick rule—the standard rule, which amounts to keeping genuine saving precisely equal to zero at each point in time, and a version that assumes a constant level of positive genuine saving[2] at each point in time. The results, in many cases, are striking.

Hypothetical Estimates of Capital Stocks

The basic methodology for testing how rich countries would be if they had followed the Hartwick rule is to compare the estimates of produced capital stocks for the year 2000 derived in chapter 2 with the size these stocks could be if countries had followed the Hartwick rule or its variants since 1970. The approach is to accumulate resource rents starting from the base-year produced capital stock in 1970.

For simplicity, it is assumed that all resource rents are invested in produced capital, although theory suggests more generally that resource rents could be invested in a range of assets, including human capital and paying down of foreign debts. If any of the countries highlighted below had been investing their resource rents in human capital[3] or foreign assets (quite unlikely given the observed levels of per capita income and indebtedness), then the methodology would produce a biased picture of their investment performance. Furthermore, since the analysis is limited to investments in produced capital, we will refer to *genuine investment* rather than *genuine saving* in what follows.

In order to examine a variety of counterfactuals, four estimates of produced capital stock are derived using data covering 1970–2000:

- A baseline capital stock derived from investment series and a Perpetual Inventory Model (PIM)—this is the same stock reported in Chapter 2
- A capital stock derived from strict application of the standard Hartwick rule
- A capital stock derived from the constant genuine investment rule
- A capital stock derived from the maximum of observed net investment and the investment required under the constant genuine investment rule. All investment and resource rent series are measured in constant 1995 dollars at nominal exchange rates.

For genuine investment I^G, net investment N, depreciation of produced capital D, and resource depletion R, the following basic accounting identities hold at any point in time:

$$I^G \equiv I - D - R \qquad (4.1)$$

$$N \equiv I - D = I^G + R \qquad (4.2)$$

For constant genuine investment $\bar{I}^G$, we therefore estimate the counterfactual series of produced capital for each country as the sum of net investments:

$$K^{*}_{2000} = K_{1970} + \sum_{t=1971}^{2000} (\bar{I}^G + R_t) \qquad (4.3)$$

$$K^{**}_{2000} = K_{1970} + \sum_{t=1971}^{2000} \max(N_t, \bar{I}^G + R_t) \qquad (4.4)$$

Here K_{1970} is the baseline stock derived from the PIM. Two versions of K* are calculated in what follows—one with $\bar{I}^G = 0$ (the standard Hartwick rule), and a second with $\bar{I}^G$ equal to a constant 5 percent of 1987 GDP. The choice of a particular level of genuine investment for the analysis is arbitrary. We use 5 percent of 1987 GDP for the following reasons: there is some logic to choosing the midpoint of our time series of data from 1970 to 2000; 1987 is a slightly better choice, falling after the recession of the early 1980s, after the collapse of oil prices in 1986, and before the recession of the early 1990s; and a 5 percent genuine investment rate is roughly the average achieved by low-income countries over time.

Resource depletion is estimated as the sum of total rents on the extraction of the following commodities: crude oil, natural gas, coal, bauxite, copper, gold, iron, lead, nickel, phosphate, silver, and zinc. These data underlie the genuine saving estimates presented in chapter 3. While the underlying theory suggests that scarcity rents are what should be invested under the Hartwick rule (that is, price minus marginal extraction cost), the World Bank data do not include information on marginal extraction costs. This gives an upward bias to the hypothetical capital stock estimates under the genuine investment rules.

When comparing estimates of the stock of produced capital for different countries, it is worth noting that the PIM underestimates the capital stock for countries with very old infrastructures, as in most European countries. The value of roads, bridges, and buildings constructed many decades and even centuries ago is not captured by the PIM. Pritchett (2000) makes a different point, that low returns on investments imply that the PIM overestimates the value of capital in developing countries. Our methodology assumes that both the PIM and cumulated net investments are, in fact, adding up productive investments. To the extent that this is not the case, estimated capital stock levels should be lower in developing countries. But the primary interest here is to compare the level of actual capital in a given country with the counterfactual level of capital in the same country, had it followed a sustainability rule. This makes the point concerning relative investment efficiency across countries less salient.

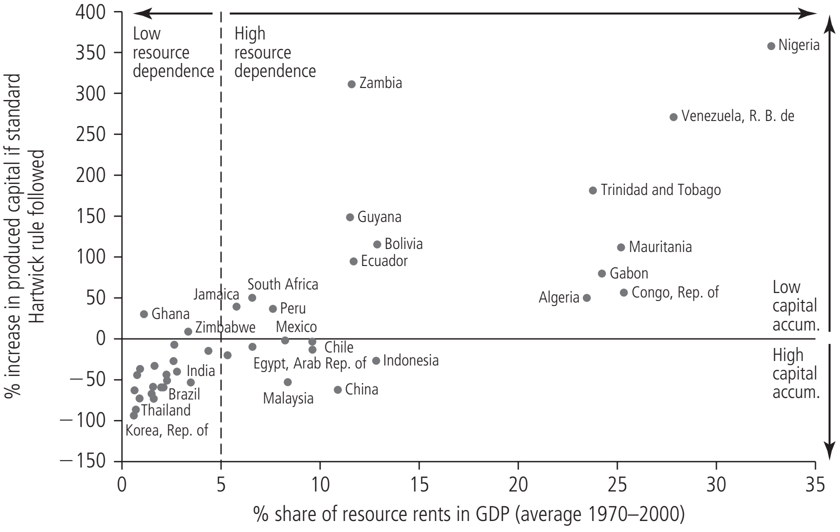
Empirical Results

How rich would countries be in the year 2000 had they followed the Hartwick rule since 1970? Based on the preceding methodology, table A4.1 (see annex) presents the year 2000 produced capital stock and the changes in this stock, which would result from the alternative investment rules. The countries shown in this table are those having both exhaustible resources and a sufficiently long-time series of data on gross investment and resource rents. For reference, the table also shows the average share of resource rents in GDP from 1970 to 2000. Negative entries in this table imply that countries actually invested more than the policy rule would suggest.

For the standard Hartwick rule, figure 4.1 scatters resource dependence, expressed as the average share of exhaustible resource rents in GDP, against the percentage difference between actual capital accumulation and counterfactual capital accumulation. Using 5 percent of GDP as the threshold for high resource dependence, figure 4.1 divides countries into the four groups shown.

The top-right quadrant of the graph displays countries with high resource dependence and a counterfactual capital stock that is higher than the actual (baseline) capital stock. The bottom-left quadrant displays countries with low natural-resource dependence and baseline capital stock that is higher than would be obtained under the Hartwick rule. These

Figure 4.1 Resource Abundance and Capital Accumulation (standard Hartwick rule)



Source: Authors.

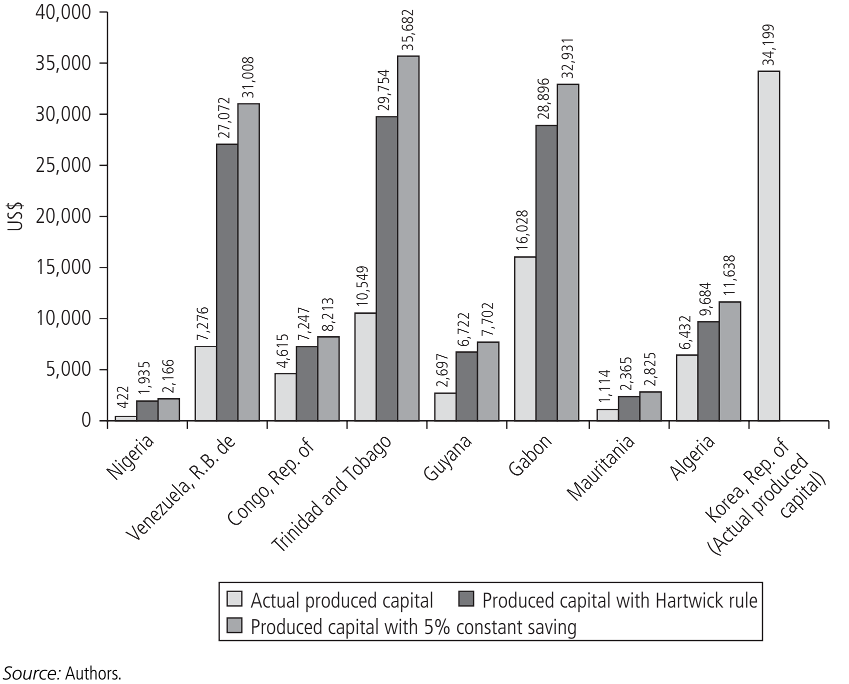
two quadrants include most of the countries in our sample, indicating a high negative correlation between resource abundance and the difference between baseline and counterfactual capital accumulation—a simple regression shows that a 1 percent increase in resource dependence is associated with a 9 percent increased difference between counterfactual and actual capital. Clearly the countries in the top-right quadrant have not been following the Hartwick rule. Economies with very low levels of capital accumulation, despite high rents, include Nigeria (oil), República Bolivariana de Venezuela (oil), Trinidad and Tobago (oil and gas), and Zambia (copper). With the exception of Trinidad and Tobago, all of these countries experienced declines in real per capita income from 1970 to 2000. In the opposite quadrant, economies with low exhaustible resource rent shares but high levels of capital accumulation include the Republic of Korea, Thailand, Brazil, and India. Some high-income countries are also in this group.

Figure 4.1 shows that no country with resource rents higher than 15 percent of GDP has followed the Hartwick rule. In many cases the differences are huge. Nigeria, a major oil exporter, could have had a year 2000 stock of produced capital five times higher than the actual stock. Moreover, if these investments had taken place, oil would play a much smaller role in the Nigerian economy today, with likely beneficial impacts on policies affecting other sectors of the economy. República Bolivariana de Venezuela could have four times as much produced capital. In per capita terms, the economies of Gabon, República Bolivariana de Venezuela, and Trinidad and Tobago, all rich in petroleum, could today have a stock of produced capital of roughly US$30,000 per person, comparable to the Republic of Korea (see figure 4.2).

Consumption, rather than investment, of resource rents is common in resource-rich countries, but there are exceptions to the trend. In the bottom-right quadrant of figure 4.1 are high resource-dependent countries that have invested more than the level of exhaustible resource rents. China, Egypt, Indonesia, and Malaysia stand out in this group, while Chile and Mexico have effectively followed the Hartwick rule—growth in produced capital is completely offset by resource depletion.

Among the countries with relatively low natural resource dependence and higher counterfactual capital, we find Ghana (gold and bauxite)

Figure 4.2 Actual and Counterfactual Produced Capital (per capita), 2000

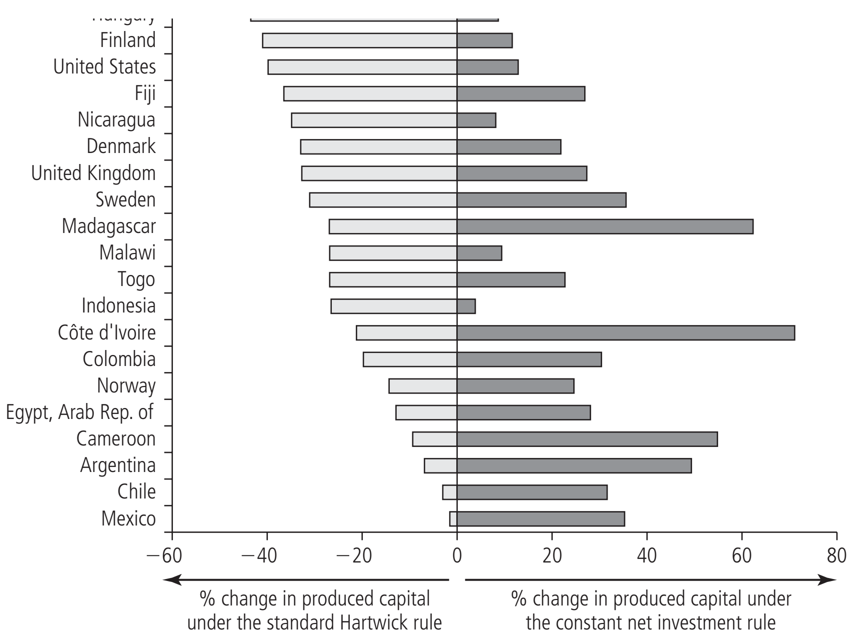


Source: Authors.
Note: 1995 dollars, nominal exchange rate.

and Zimbabwe (gold). This is indicative of very low levels of capital accumulation in these economies.

Figure 4.3 highlights countries which have invested more than their resource rents (as shown by the negative entries on the left side of the figure) but have failed to maintain constant genuine investment levels of at least 5 percent of 1987 GDP (as shown by the entries on the right). Developing countries in this group include Argentina, Cameroon, Cote d'Ivoire, and Madagascar. A number of high-income countries also appear in the figure. Sweden could have a stock of capital 36 percent higher if it had maintained constant genuine investment levels at the specified target. The corresponding difference for the United Kingdom is 27 percent, for Norway 25 percent, and for Denmark 22 percent.[4] The generally low level of genuine investment levels in the Nordic countries is particularly surprising. Are these countries trading off intergenerational equity against intragenerational equity? Further research would be required to clarify this, a question that is beyond the scope of this chapter.

Figure 4.3 Capital Accumulation under the Hartwick and Constant Net Investment Rules



Source: Authors.

The next-to-last column in table A4.1 shows the change in produced assets for countries if they had genuine investments of at least 5 percent of 1987 GDP. The positive figures indicate that, with the exception of Singapore, all countries experienced at least one year from 1970 to 2000 where genuine investments were less than the prescribed constant level.

Conclusions

Applying the standard Hartwick rule as development policy would be extreme. It implies a commitment to zero net saving for all time. Conversely, the constant genuine saving rule embodies a commitment to building wealth at each point in time. In a risky world this may be a more palatable development policy.

The Hartwick rule counterfactual calculations show how even a moderate saving effort, equivalent to the average saving effort of the poorest countries in the world, could have substantially increased the wealth of resource-dependent economies. Of course, for the most resource-dependent countries such as Nigeria there is nothing moderate about the implied rate of investment. A Nigerian genuine investment rate of 36.1 percent of GDP in 1987 is what the calculations suggest under the constant genuine investment rule.

The saving rules presented here are appealing in their simplicity. Maintaining a constant level of genuine saving will yield a development path where consumption grows monotonically, even as exhaustible resource stocks are run down. The real world is more complex. Poor countries place a premium on maintaining consumption levels, with negative effects on saving—the alternative may be starvation. At the same time financial crises, social instability, and natural disasters all have deleterious effects on saving. Holding to a simple policy rule in such circumstances would be no small feat.

Saving effort is of course not the whole story in sustaining development. Saving must be channeled into productive investments that can underpin future welfare, rather than high-profile but ultimately nonremunerative projects. As Sarraf and Jiwanji (2001) document, Botswana's successful bid to avoid the resource curse was built upon a whole range of sound macroeconomic and sectoral policies, underpinned by a positive political economy.

Endnotes

1. See Auty (2001), ch. 1 for a good overview. One of the earliest studies was Sachs and Warner (1995).

2. See Hamilton and Hartwick (2005). This chapter builds upon Hamilton and others (forthcoming).

3. In support of the point that high natural resource rents are not necessarily invested in human capital, Gylfason (2001) shows that public expenditure on education relative to national income and gross secondary-school enrollment is inversely related to the share of natural capital in national wealth across countries. Natural capital appears to crowd out human capital.

4. A sensitivity test shows that these results hold by and large for most countries in the group. A change of the investment rule to 4 per cent of 1987 GDP affects qualitatively only those countries for which the change in produced capital was relatively small: Hungary, Finland, and Indonesia.

Annex

Table A4.1 Change in Produced Assets under Varying Rules for Genuine Investment (I^G)

	Produced capital in 2000, $bn (1995 dollars)	$I^G = 0$ % difference	I^G = 5% of 1987 GDP % difference	I^G >= 5% of 1987 GDP % difference	Rent per GDP average % (1970–2000)
Nigeria	53.5	358.9	413.6	413.6	32.6
Venezuela, R. B. de	175.9	272.1	326.1	326.1	27.7
Congo, Rep. of	13.9	57.0	78.0	116.9	25.2
Mauritania	3.0	112.3	153.7	154.0	25.0
Gabon	19.7	80.3	105.5	130.4	24.1
Trinidad and Tobago	13.7	182.1	238.3	239.1	23.6
Algeria	195.4	50.6	80.9	83.9	23.3
Bolivia	13.7	116.1	169.8	177.5	12.8
Indonesia	540.6	–26.5	3.8	32.1	12.5
Ecuador	37.7	95.3	158.0	158.3	11.6
Zambia	7.5	312.3	383.4	388.0	11.5
Guyana	2.1	149.3	185.6	191.2	11.4
China	2,899.4	–62.1	–45.0	5.1	10.8
Egypt, Arab Rep. of	159.7	–12.9	28.1	36.2	9.5
Chile	151.4	–3.0	31.6	54.0	9.5
Malaysia	305.2	–52.7	–31.4	6.6	8.3
Mexico	975.5	–1.5	35.3	42.2	8.2
Peru	132.3	37.2	98.1	103.9	7.5
Cameroon	24.1	–9.3	54.8	67.6	6.5
South Africa	349.5	50.7	109.3	115.8	6.5
Jamaica	13.4	39.9	87.8	99.6	5.7
Colombia	198.0	–19.7	30.4	39.3	5.3
Norway	456.6	–14.3	24.6	33.0	4.3
India	965.4	–52.9	–18.3	8.6	3.4
Zimbabwe	14.9	9.1	64.8	89.1	3.3
United States	16,926.7	–39.8	12.9	26.1	2.7
Argentina	569.6	–6.9	49.4	53.9	2.6
Togo	3.6	–26.8	22.7	55.1	2.6

	Produced capital in 2000, \$bn (1995 dollars)	$I^G = 0$ % difference	I^G = 5% of 1987 GDP % difference	I^G >= 5% of 1987 GDP % difference	Rent per GDP average % (1970–2000)
Pakistan	125.6	–50.7	–1.7	11.1	2.2
Hungary	149.1	–43.5	8.7	22.3	2.2
Morocco	93.8	–59.1	–16.3	7.8	2.0
Brazil	1,750.5	–59.0	–6.6	9.1	1.9
United Kingdom	2,400.1	–32.7	27.3	32.8	1.6
Dominican Republic	33.8	–73.0	–27.9	1.2	1.6
Philippines	195.0	–58.4	–14.5	10.6	1.5
Honduras	12.3	–66.9	–29.7	8.9	1.5
Ghana	16.1	30.6	73.2	76.7	1.0
Fiji	3.6	–36.5	26.9	59.3	0.9
Benin	4.6	–72.7	–21.7	10.6	0.8
Senegal	10.0	–44.0	14.2	27.5	0.7
Thailand	520.6	–86.3	–63.6	3.0	0.7
Haiti	2.8	–62.7	109.2	109.5	0.6
Korea, Rep. of	1,607.6	–93.5	–68.6	0.9	0.6
Israel	215.8	–72.8	–31.3	4.2	0.5
Côte d'Ivoire	16.1	–21.2	71.1	108.7	0.5
Bangladesh	89.7	–59.0	–12.9	15.5	0.5
Rwanda	3.9	–83.2	–6.9	24.6	0.4
Sweden	508.0	–31.1	35.6	36.1	0.4
Nicaragua	6.9	–34.9	8.1	44.8	0.3
Spain	1,623.6	–58.9	–15.1	6.1	0.3
Denmark	437.2	–33.0	21.9	28.7	0.2
France	3,724.7	–55.0	–1.9	6.9	0.1
Italy	2,711.2	–44.8	7.5	10.2	0.1
Finland	347.6	–40.9	11.6	23.3	0.1
Belgium	681.9	–48.0	2.3	10.4	0.1
Niger	3.0	9.7	95.2	136.1	0.1
Burundi	1.6	–87.3	10.1	30.2	0.1
Portugal	308.8	–71.0	–30.8	5.7	0.0
Costa Rica	24.1	–80.0	–30.6	3.6	0.0

Continued

Table A4.1 (Continued)

	Produced capital in 2000, $bn (1995 dollars)	$I^G = 0$ % difference	$I^G = 5\%$ of 1987 GDP % difference	$I^G >= 5\%$ of 1987 GDP % difference	Rent per GDP average % (1970–2000)
El Salvador	17.1	–59.7	–2.5	24.6	0.0
Hong Kong, China	445.9	–88.6	–56.4	0.9	0.0
Kenya	20.1	–51.9	2.0	20.8	0.0
Madagascar	4.9	–26.9	62.4	65.5	0.0
Sri Lanka	41.2	–88.1	–55.4	1.0	0.0
Malawi	4.6	–26.8	9.4	68.2	0.0
Uruguay	29.9	–55.5	22.1	37.2	0.0
Luxembourg	43.3	–63.2	–22.0	15.7	0.0
Paraguay	23.7	–88.6	–46.6	3.0	0.0
Lesotho	5.7	–95.7	–79.9	0.1	0.0
Singapore	314.8	–92.7	–73.2	0.0	0.0

Source: Authors.
Note: Negative entries indicate that hypothetical produced assets would be lower than observed assets under the specified rule.

Chapter 5

The Importance of Population Dynamics: Changes in Wealth per Capita

Adjusted net, or genuine, saving was introduced in chapter 3. As a more-inclusive measure of net saving effort, one that includes depletion and degradation of the environment, depreciation of produced assets, and investments in human capital, genuine saving provides a useful indicator of sustainable development. The underlying theory (Hamilton and Clemens 1999) shows that negative rates of genuine saving imply future declines in utility along the optimal growth path for the economy. 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. See box 1.1 for an overview of the theoretical work linking net saving to changes in welfare.

If population is not static, then it is clearly per capita welfare that policy should aim to sustain. Genuine saving measures the real change in value of total assets rather than the change in assets per capita. Genuine saving answers an important question: Did total wealth rise or fall over the accounting period? However, 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 in total could be positive while wealth per capita is declining.

A simple formula, which assumes that the population grows exogenously, makes the accounting clear. If total wealth is denoted W, population P, and population growth rate *g*, then the change in wealth per capita can be shown to equal:

$$\Delta\left(\frac{W}{P}\right) = \frac{\Delta W}{P} - g \cdot \frac{W}{P} = \frac{W}{P}\left(\frac{\Delta W}{W} - g\right) \qquad (5.1)$$

If we interpret ΔW as genuine saving, then the first equality says that the change in wealth per capita equals genuine saving per capita minus a Malthusian term, the population growth rate times total wealth per capita. A growing population implies that existing wealth must be shared with each new cohort entering the population. More intuitively, the second equality in equation 5.1 says that total wealth per capita will rise or fall depending on whether the growth rate of total wealth ($\Delta W/W$) is higher or lower than the population growth rate.

This chapter applies the formula for changes in wealth per capita provided in equation 5.1 to the wealth database for the year 2000. The interplay of saving effort and population growth turns out to be quite significant.

Accounting for Changes in Wealth per Capita: A Ghanaian Example

Measuring saving and wealth in per capita terms requires some changes to the accounting framework presented in chapters 2 and 3. The first point is that we wish to measure only total *tangible* wealth, excluding intangible capital, when calculating the change in wealth per capita. Roughly speaking, the intuition behind this is that much intangible capital is *embodied* in the population.

An adjustment should be made to the calculation of adjusted net saving. The underlying accounting framework suggests that a growing population, through a Malthusian effect, as described above, should actually boost saving per person when the stock of carbon dioxide historically emitted by a given country is taken into account. This potentially offsets the effect of current emissions per person. Since no data on stocks of carbon dioxide emitted by country are available, we simplify the accounting by dropping value of emissions per person.

Table 5.1 Ghana: Calculating the Change in Wealth
— $ per capita —

Tangible wealth		Adjusted net saving	
Subsoil assets	65	Gross national saving	40
Timber resources	290	Education expenditure	7
NTFR	76	Consumption fixed capital	19
Protected areas	7	Energy depletion	0
Cropland	855	Mineral depletion	4
Pastureland	43	Net forest depletion	8
Produced capital	686		
Total tangible wealth	2022	Adjusted net saving	16
Population growth	1.7%	Δ Wealth per capita	–18

Source: Authors.
Note: Data for 2000. NTFR: nontimber forest resources.

Table 5.1 displays the detailed accounting of the change in wealth per capita in Ghana, a country with a 1.7 percent population growth rate per year. The left-hand column shows the assets that compose tangible wealth, summed to yield total tangible wealth per capita. The right-hand column breaks out the accounting of adjusted net saving. Gross national saving is added to education expenditures to yield total saving effort; consumption of fixed capital and natural resource depletion are then subtracted from this total to yield the net saving per Ghanaian, $16. The population growth rate is then multiplied by tangible wealth (the Malthusian term) and the result subtracted from adjusted net saving to yield the bottom-line change in wealth, –$18 per Ghanaian. The rate of change of total real wealth ($16/$2,022 = 0.8 percent) is less than the population growth rate.

Changes in Wealth per Capita in Selected African Countries

Table 5.2 summarizes the results of this accounting for the African countries in the wealth database. The gross national income (GNI) per capita and population growth rates are provided for reference in the table. Adjusted net saving excludes carbon dioxide emissions, as described above.

Table 5.2 Africa: Change in Wealth per Capita 2000
— $ per capita —

	GNI per capita	Population growth rate (%)	Adjusted net saving per capita	Change in wealth per capita	Saving gap (% GNI)
Benin	360	2.6	14	–42	11.5
Botswana	2,925	1.7	1,021	814	
Burkina Faso	230	2.5	15	–36	15.8
Burundi	97	1.9	–10	–37	37.7
Cameroon	548	2.2	–8	–152	27.7
Cape Verde	1,195	2.7	43	–81	6.8
Chad	174	3.1	–8	–74	42.6
Comoros	367	2.5	–17	–73	19.9
Congo, Rep. of	660	3.2	–227	–727	110.2
Côte d'Ivoire	625	2.3	–5	–100	16.0
Ethiopia	101	2.4	–4	–27	27.1
Gabon	3,370	2.3	–1,183	–2,241	66.5
Gambia, The	305	3.4	–5	–45	14.6
Ghana	255	1.7	16	–18	7.2
Kenya	343	2.3	40	–11	3.2
Madagascar	245	3.1	9	–56	22.7
Malawi	162	2.1	–2	–29	18.2
Mali	221	2.4	20	–47	21.2
Mauritania	382	2.9	–30	–147	38.4
Mauritius	3,697	1.1	645	514	
Mozambique	195	2.2	15	–20	10.0
Namibia	1,820	3.2	392	140	
Niger	166	3.3	–10	–83	50.3
Nigeria	297	2.4	–97	–210	70.6
Rwanda	233	2.9	14	–60	26.0
Senegal	449	2.6	31	–27	6.1
Seychelles	7,089	0.9	1,162	904	
South Africa	2,837	2.5	246	–2	0.1
Swaziland	1,375	2.5	129	8	
Togo	285	4.0	–20	–88	30.8
Zambia	312	2.0	–13	–63	20.4
Zimbabwe	550	2.0	53	–4	0.7

Source: Authors.
Note: All dollars at market exchange rates.

The table introduces a new performance indicator, the *saving gap* as a share of GNI. This is a measure of how much extra saving effort would be required in order for a country to break even with zero change in wealth per capita. It is calculated by identifying negative changes in wealth per capita, a measure of how far countries are from the break-even point, then dividing this by GNI per capita. South Africa is effectively at the point where wealth creation just offsets population growth.

This table shows that the generally high rates of population growth in African countries translate into very few countries with growing wealth per capita—Botswana,[1] Mauritius, Namibia, Seychelles, and Swaziland. These positive examples show that a Malthusian outcome is not inevitable. Sound resource policies combined with sound macroeconomic policies can lead to wealth creation.

A long list of African countries exhibits positive net saving per capita, but negative changes in total wealth per capita. These include Benin, Burkina Faso, Cape Verde, Ghana, Kenya, Madagascar, Mali, Mozambique, Rwanda, Senegal, and Zimbabwe. Population growth is outstripping wealth creation in these countries.

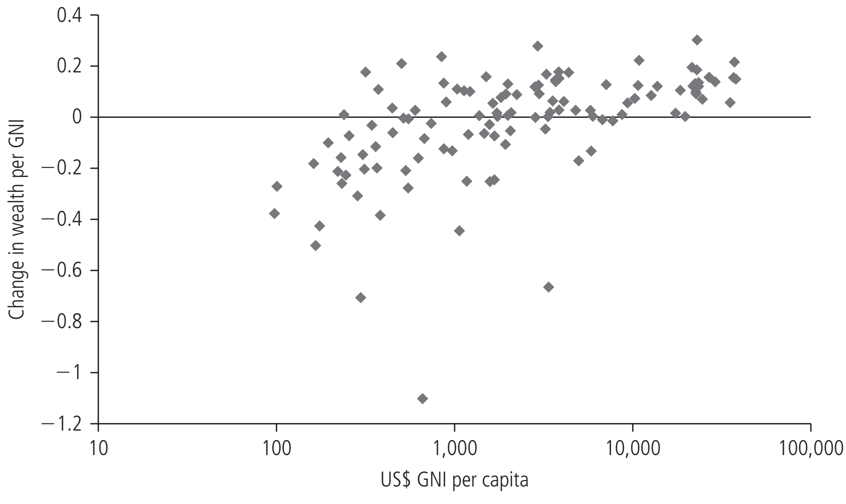
The oil states—the Republic of Congo, Gabon, and Nigeria—stand out in table 5.2 for enormous saving gaps (more than 100 percent of GNI in the case of the Republic of Congo). These countries are both running down total assets (as measured by negative adjusted net saving) and experiencing the immiserating effects of high population growth rates.

Changes in Wealth per Capita Across Countries

Figures 5.1 and 5.2 summarize changes in wealth per capita across all 118 countries in the database. The first figure scatters change in wealth per capita as a share of GNI against GNI per capita. The aim is to see how saving performance is linked to levels of income. The second figure looks at the correlation of net saving per capita with population growth rates.

As figure 5.1 shows, the broad picture is that the rich are getting richer while the poor are getting poorer. There is an upward trend to the scatter,

Figure 5.1 Change in Wealth per GNI vs. GNI per Capita, 2000



Source: Authors. Data on GNI per capita are from World Bank 2005.

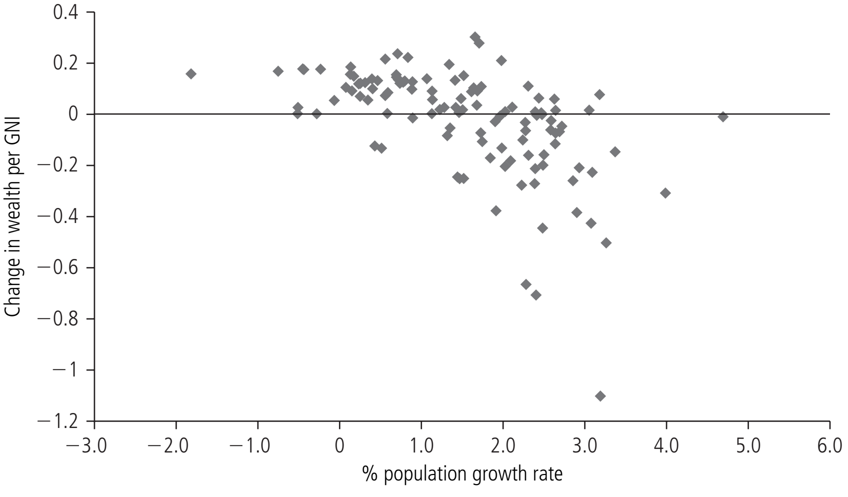
and the majority of countries with GNI of less than $1,000 per person have declines in wealth per capita. Low levels of saving in poor countries are well-known phenomena, but factoring in population growth accentuates this trend markedly.

The downward trend in figure 5.2 shows that high population growth rates are associated with lower net accumulation of wealth per person. Empirically, the majority of countries with population growth rates above 1.5 percent a year are on a path of declining wealth per capita. The figure shows a cluster of countries with population growth rates between 2 percent and 3 percent and positive accumulation of wealth per capita. Countries such as Namibia, the Philippines, and Jordan show that, as noted above, Malthusian outcomes are not inevitable.

The table in appendix 4 reports results on changes in wealth per capita and saving gaps across all countries in the database, using the same structure as table 5.2.

The oil producers joining the list of countries with high saving gaps (greater than 10 percent of GNI) include Syria, Iran, Ecuador, Algeria, República Bolivariana de Venezuela, and Trinidad and Tobago. Both in total and on a per capita basis these countries are running down their assets. Studies of historical data have shown that

Figure 5.2 Change in Wealth per GNI vs. Population Growth Rate, 2000



Source: Authors. Data on population growth are from World Bank 2005.

countries combining high dependence on resource extraction and negative net saving rates have lagged the growth performance of other countries (Atkinson and Hamilton 2003).

Finally, many of the countries of Eastern Europe and Central Asia are experiencing population declines, which raises saving per capita according to the formula underlying the saving calculation. These countries include Bulgaria, Estonia, Georgia, Hungary, Latvia, Moldova, Romania, and the Russian Federation. While, in principle, shrinking populations increase assets per capita, there is no guarantee that this will increase welfare per capita if these assets are not used efficiently.

Conclusions

Before drawing the main conclusions from this analysis, it is important to note some alternative models of adjusted net saving. First, one of the largest potential factors offsetting dissaving is technological change. If technological change can be considered to be exogenous, then the effect of growth in total factor productivity has to be built into the saving analysis. While for high-income countries the adjustment to saving could be very large,[2] total factor productivity growth in low-income countries has been extremely low or negative.

Second, if population growth were endogenous, then this could potentially have an impact on countries' prospects for future welfare. For example, if fertility were negatively related to wealth per person, then countries that are calculated to have negative changes in wealth per capita could potentially face higher birthrates and a downward spiral of immiseration. This would tend to emphasize the importance of the figures presented here.

The Ghanaian example shows that it is indeed possible to have positive genuine saving in total, but declining wealth per person. Countries with high population growth rates are effectively on a treadmill, and need to create new wealth just to maintain existing levels of wealth per capita.

Table 5.2 suggests very large saving gaps in Sub-Saharan Africa when population growth is taken into account. Excluding the oil states, saving gaps in many countries are on the order of 10–50 percent of GNI. Against this must be set the realization that reigning in government consumption by even a few percentage points of GNI is extremely painful and often politically perilous. Macroeconomic policies alone seem unlikely to close the gap.

The table in appendix 4 shows that large saving gaps are not strictly a Sub-Saharan African phenomenon. Selected countries in the Middle East and North Africa, Latin America and the Caribbean, East Asia, and South Asia also have significant saving gaps. Although wealth data are lacking, given their sharply negative genuine saving rates (reported in chapter 3) and moderate population growth rates, it is highly likely that the oil states in Central Asia (Azerbaijan, Kazakhstan, and Uzbekistan) also face large saving gaps.

Against this rather bleak picture there are the examples of countries that, even in the face of high population growth rates, have managed to achieve positive rates of wealth accumulation per capita. Policy clearly matters, both in the resource and macroeconomic domains. The next chapter examines, using historical data, whether the model of saving presented here is overstringent in its assumptions about the effects of population growth.

Endnotes

1. Botswana has relatively low population growth and a sizable increase in wealth per capita, but the lack of data on diamonds in the wealth database means that this is a highly distorted picture.

2. Weitzman and Löfgren (1997) calculate a boost to United States GDP on the order of 40 percent from exogenous technological changes. Total factor productivity measures the contribution to economic growth that cannot be strictly attributed to accumulation of produced capital or labor.

Chapter 6

TESTING GENUINE SAVING

Intuition suggests that saving today should have an effect on future economic performance, and indeed, the large body of work on across-country analysis of economic growth supports this (Sala-i-Martin 1997; Hamilton 2005; Ferreira and others 2003; Ferreira and Vincent 2005). The literature on genuine saving makes a prediction that is eminently testable: current saving should equal the change over the accounting period in the present value of future well-being along the optimal growth path of the economy. The proposition that net saving is equal to changes in well-being has been proved in the literature. See box 1.1 for more details.

The empirical test of this prediction exploits the 30-plus-year time series on genuine saving described in chapter 3 and published every year in the *World Development Indicators* (WDI) (World Bank 2005). With these historical data it is possible to ask whether measured genuine saving in 1980 actually equaled the present value of changes in consumption as measured in the consumption time series. While the data may not fit the theory perfectly for any individual country, the analysis is carried out across countries to see whether statistically there is a good fit of the data to the theory.

One problem with designing an empirical test concerns the restrictiveness of the underlying model of the economy. Many of the models in the literature on saving and sustainability assume optimality, in the sense of the economy actually maximizing the present value of social well-being at each point in time, as well as fixed interest rates and constant returns to scale. Each of these assumptions is likely to be violated in real-world economies, which limits the feasibility of testing the models with historical data.

These difficulties notwithstanding, testing alternative measures of saving is important if policy makers are to be convinced to use a measure such as genuine saving as a performance measure for the economy.

Specifying the Empirical Test

Recent theoretical work provides a model of the linkage between saving and future well-being that shares few of the theoretical restrictions of earlier work (Hamilton and Hartwick 2005; Hamilton and Withagen 2004). Two basic assumptions are required:

- Economies are competitive, in the sense that producers are free to maximize profits, while households are free to maximize well-being.
- Externalities are internalized. For example, pollution taxes are employed to ensure that prices reflect the damages that producers inflict on households when a pollutant is emitted.

The first assumption is valid for many economies. The second assumption is valid for relatively few economies, but the empirical literature on pollution damages suggests that the size of the impact is likely to be small in most economies.

Under these assumptions it is possible to define the following basic relationship between the measure of change in total real wealth per capita G and changes in consumption C per capita:

$$G_0 = \sum_{t=1}^{T} \frac{1}{(1+r)^t} \cdot \left(\frac{C_t}{N_t} - \frac{C_{t-1}}{N_{t-1}} \right) \tag{6.1}$$

Here N is total population, r is the discount rate, and T is an assumed time period for the analysis. This expression just says that current change in total wealth per capita should equal the present value of changes in consumption per capita.

Assuming this relationship holds, then it is possible to test it econometrically as:

$$PVC_i = \alpha + \beta \cdot G_i + \varepsilon_i \tag{6.2}$$

where G_i is one of several alternative measures of saving for country i, while PVC_i is the present value of changes in future consumption as suggested by the expression above. If the data fit the theory, then we would expect $\alpha = 0$ and $\beta = 1$.

The World Bank's time series of saving data permit tests of alternative measures of saving. Four different measures are tested, as follows:

- *Gross* saving is just gross national income (GNI) minus total consumption in the private and public sectors—it is the amount of output that is not consumed in any given year. Gross saving is the figure typically reported and used by ministries of finance.
- *Net* saving deducts the depreciation of produced capital from gross saving.
- *Adjusted net* or *genuine* saving deducts the depletion of natural resources and pollution damages from net saving.
- *Malthusian* saving[1] measures the change in total real wealth per capita as defined in chapter 5—it is equal to genuine saving per capita, minus the population growth rate times the value of tangible wealth per capita.

Data and Methodology of Estimation

The time series data for the analysis—GNI, gross saving, consumption of fixed capital,[2] and depletion of natural resources (energy, minerals, and net forest depletion)—are taken directly from the WDI (World Bank 2005). Total tangible wealth, employed in the Malthusian saving calculation, is derived using a perpetual inventory model (PIM) for produced capital stock estimates (the same model used in arriving at the total wealth estimates for 2000 presented in chapter 2 and elsewhere); present values of mineral and energy rents; and present values of forestry, fishing, and agricultural rents, all measured in constant 1995 dollars (Ferreira and others 2003).

Public expenditures on education are excluded from the genuine and Malthusian saving measures. These were shown to perform exceedingly badly in earlier econometric tests of saving by Ferreira and Vincent (2005). There are a number of plausible reasons for the poor performance:

- These are gross, rather than net, investment estimates.
- Private education expenditures are excluded.
- Expenditures may be a very poor proxy for human capital formation, particularly in developing countries (Pritchett 1996).

Damages from carbon dioxide emissions are also excluded from the saving measures. This is partly because the bulk of the damages occur in the longer term, but also because, in the absence of a binding agreement to pay compensation, damages to other countries (the major effect of emitting carbon dioxide) should have no effect on future consumption in the emitting country.

One of the key choices to be made in estimating the expression for saving econometrically is the choice of period over which to calculate changes in consumption. The underlying theory suggests that there is, in principle, an infinite time horizon. As a practical matter, however, the data on genuine saving are limited to the period 1970–2000, with data for the early 1970s being particularly sparse.

A reasonable choice of time horizon would be the mean lifetime of produced capital stocks, roughly 20 years (machinery and equipment lifetimes are typically shorter, 10 years or so, but buildings and infrastructure have lifetimes of several decades). Choosing 20 years would be saying, in effect, that the effects of saving will be felt over the lifetime of the produced capital in which they are presumed to be invested. This is the assumption used below, and testing the estimation for a 10-year time horizon produced less robust estimates overall (in terms of explained variation, probability of rejecting a linear relationship between dependent and independent variables, and significance of the coefficients on saving).

The other decision required for estimation concerns the discount rate. The underlying theory (Ferreira and others 2003) suggests that the rate should be the marginal product of capital, less depreciation rates for produced capital, less population growth rates, which argues for a low value. We use a uniform rate of 5 percent, and tests of alternatives suggest that the estimates are fairly insensitive to small changes in the discount rate.

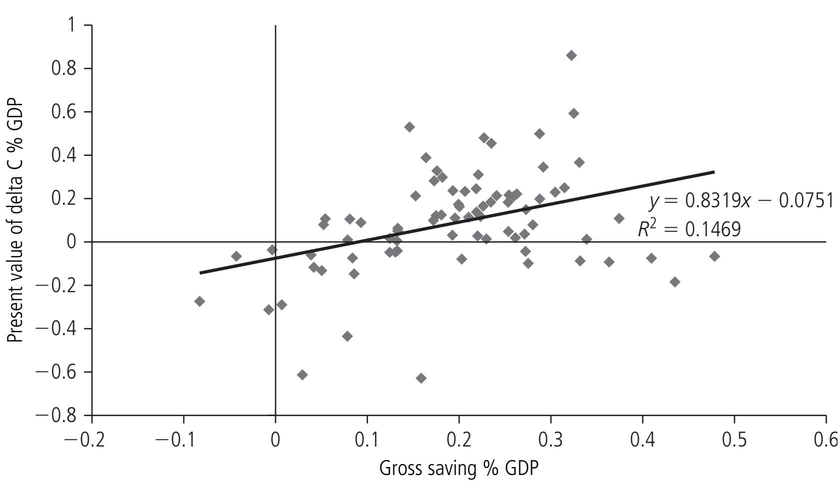
Allowing for the sparse early-1970s saving data,[3] therefore, the regression equation was estimated using Ordinary Least Squares (OLS) for consecutive 20-year periods from 1976 to 1980. These results, as well as more informal methods, are reported below.

Empirical Results

To provide a feel for the data, we first scatter the present value of changes in consumption against the four different saving measures for 1980 in figures 6.1–6.4. The broad picture which emerges is that there is no monotonic improvement in the fit with theory as more stringent measures of saving are applied. The coefficient on saving actually drops from gross saving to net saving, and the explained variation drops considerably. For genuine saving the coefficient on saving is higher and very near one. Finally, for Malthusian saving the coefficient on saving drops to the lowest level of the four measures, while explained variation reaches its highest value.

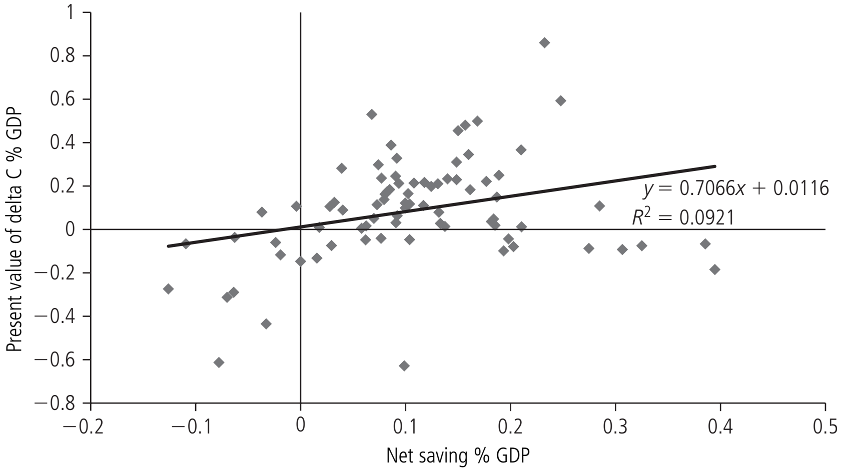
Figure 6.5 presents the same scatter for high-income countries only. As seen in Ferreira and Vincent (2005) and Ferreira and others (2003), the model fit is particularly poor for these countries. Further tests show the coefficient on saving to be insignificant, while the explained variation is very low.

Figure 6.1 Present Value of Change in Consumption vs. Gross Saving, 1980



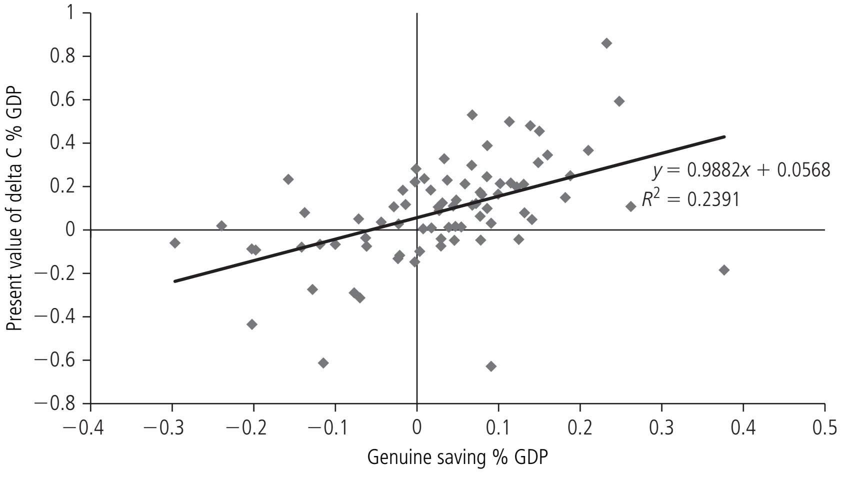
Source: Authors.

Figure 6.2 Present Value of Change in Consumption vs. Net Saving, 1980



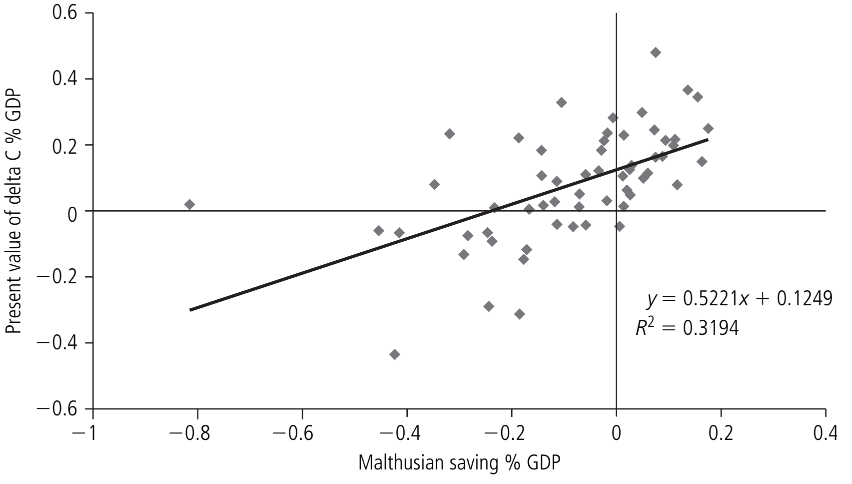
Source: Authors.

Figure 6.3 Present Value of Change in Consumption vs. Genuine Saving, 1980



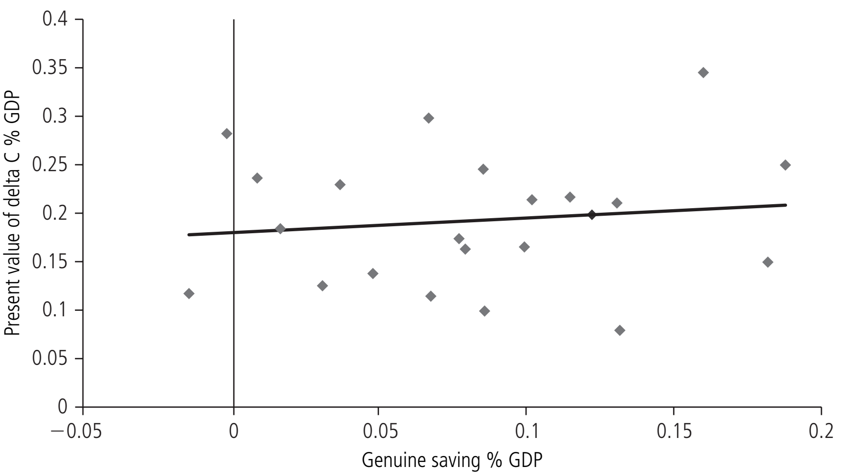
Source: Authors.

Figure 6.4 Present Value of Change in Consumption vs. Malthusian Saving, 1980



Source: Authors.

Figure 6.5 Present Value of Change in Consumption vs. Genuine Saving, High-Income Countries, 1980



Source: Authors.

Table 6.1 Regression Results for PVC = alpha + beta √Saving

	1976		1977		1978		1979		1980	
	beta	alpha	beta	alpha	beta	alpha	beta	alpha	beta	alpha
Gross saving										
Coeff.	1.0152	–0.0737	0.7596	–0.0338	1.0484	–0.1212	1.2325	–0.1743	0.8319	–0.0751
tstat	3.0335	–0.9511	2.4358	–0.4628	3.7257	–1.8992	4.7372	–2.8601	3.6416	–1.4656
R^2	0.1479		0.0803		0.1598		0.2351		0.1469	
Df	53		68		73		73		77	
Pr > F	0.0037		0.0175		0.0004		0.0000		0.0005	
beta = 1	0.0445		–0.7595		0.1697		0.8814		–0.7264	
Net saving										
Coeff.	0.6634	0.0606	0.2161	0.1047	0.6485	0.0209	0.9835	–0.0293	0.7066	0.0116
tstat	1.7723	1.0787	0.6471	2.0414	1.9740	0.4433	3.2791	–0.6574	2.7943	0.3102
R^2	0.0560		0.0061		0.0507		0.1284		0.0921	
Df	53		68		73		73		77	
Pr > F	0.0821		0.5198		0.0522		0.0016		0.0066	
beta = 1	–0.8823		–2.3125		–1.0555		–0.0542		–1.1451	
Genuine saving										
Coeff.	1.2803	0.0483	0.8532	0.0677	1.2553	0.0131	0.7815	0.0580	0.9882	0.0568
tstat	4.5524	1.4442	3.4246	2.1915	4.9943	0.4654	4.2716	2.3469	4.9187	2.3175
R^2	0.2811		0.1471		0.2547		0.2000		0.2391	
Df	53		68		73		73		77	
Pr > F	0.0000		0.0010		0.0000		0.0001		0.0000	
beta = 1	0.9780		–0.5808		1.0019		–1.1781		–0.0578	
Malthusian saving										
Coeff.	0.7757	0.1337	0.5741	0.1200	0.4663	0.1061	0.3599	0.1117	0.5221	0.1249
tstat	3.8801	5.1418	3.2489	5.0664	4.0371	5.0553	3.7425	5.2683	5.1265	6.1294
R^2	0.2785		0.1772		0.2352		0.2030		0.3194	
Df	39		49		53		55		56	
Pr > F	0.0004		0.0021		0.0002		0.0004		0.0000	
beta = 1	–1.0937		–2.3613		–4.5343		–6.5358		–4.6100	

Source: Authors.

Table 6.1 presents the results of the individual OLS estimates of the model for each of the five years and four measures of saving. This table reports the coefficient values with t-statistics, R-squared, degrees of freedom, the probability of rejecting a linear relationship (from the F statistic), and a simple two-sided t-test of whether the coefficient on saving is equal to 1 (values greater than 2.00 imply the coefficient is significantly different from 1 at the 5 percent confidence level). While there is some heterogeneity in the results, the following broad conclusions hold:

- The results for 1977 are the weakest of the five years, with low R-squared, higher probabilities of rejecting a linear relationship than other years, and two saving coefficient estimates that are significantly different from one (although the coefficient for net saving is not itself significant). This suggests some systematic shock being picked up by the data for this year.
- Results for net saving are generally the weakest of the four saving measures tested, with insignificant coefficients on saving at the 5 percent level in 1976 and 1977, and generally low R-squared and higher probability of rejecting a linear relationship than other measures.
- Malthusian saving exhibits the worst fit with theory, with the coefficients on saving being the lowest of the four saving measures, and significantly different from one in four out of the five years tested.
- The results for gross and genuine saving have similarities, with the coefficients on saving being significant and not significantly different from one in all years. Genuine saving explains much more of the total variation in four out of five years, and exhibits lower probability of rejecting a linear relationship in the same four years, suggesting a more robust fit with theory.

Quantitative analysis suggests a moderate advantage to using genuine saving as a predictor of future welfare, in the sense of a one percentage-point change in saving translating into a 1 percent change in the present value of changes in future consumption. Figures 6.1 and 6.3 suggest a more qualitative test. In Figure 6.1 it can readily be seen that gross saving provides many *false positives* in the form of positive base-year saving translating into negative welfare outcomes—these are the scatter points lying in the lower-right quadrant. Similarly, the upper-left quadrant points in figure 6.3 represent *false negatives*—countries where negative base-year genuine saving was associated with increases in welfare.

Table 6.2 False Signals regarding Future Changes in Consumption (ratios)

	1976	1977	1978	1979	1980	Wt. avg.
Gross saving						
False positive	0.241	0.246	0.320	0.360	0.267	0.294
False negative	1.000	0.000	0.000	0.000	0.000	0.167
Net saving						
False positive	0.226	0.250	0.275	0.338	0.209	0.266
False negative	0.500	0.500	0.167	0.250	0.167	0.231
Genuine saving						
False positive	0.188	0.200	0.226	0.293	0.154	0.218
False negative	0.429	0.400	0.231	0.412	0.407	0.378
Malthusian saving						
False positive	0.043	0.080	0.037	0.077	0.043	0.056
False negative	0.611	0.615	0.464	0.452	0.600	0.543

Source: Authors.

Table 6.2 assembles the proportions of false positives and false negatives[4] for all saving measures, for all years, along with an average for each saving measure weighted by the number of countries with positive or negative saving observed. A few observations:

- Malthusian saving has the lowest proportion of false positives, but in fact, the vast majority of the countries with positive Malthusian saving are developed countries. The result is therefore unsurprising. This saving measure also has the highest proportion of false negatives, which is consistent with the results of the quantitative analysis.
- Gross and net saving have relatively low proportions of false negatives, but this represents very few countries (only one in the case of gross saving) across all years. There are simply very few countries with negative gross or net saving.
- Genuine saving has lower proportions of false positives than either gross or net saving, but this is balanced by a much higher proportion of false negatives.

Conclusions

Growth theory provides the basis for a stringent test of whether saving does, in fact, translate into future welfare. This chapter confronts the theory with real-world data—with positive results for measures of gross and genuine saving. Even without appealing to theoretical models, it may be asked when a dollar is saved how it could *not* show up in future production and consumption. Many answers to this question are possible:

- Saving may be measured very badly.
- Funds appropriated for public investments may not, in fact, be invested, owing to problems of governance.
- Investments, particularly by the public sector, may not be productive.

It is important to note the many caveats pertaining to this analysis. First, measurement error may be significant, particularly for consumption of fixed capital (where government estimates may be incorrect), depletion of natural resources (where World Bank resource rent estimates depend on rather sparse cost of extraction data, and where the methodology probably inflates the value of depletion for countries with large resource deposits), and total wealth estimates (especially produced capital in developing countries, where public investments may be particularly inefficient [Pritchett 2000]).

Missing variable bias may also be an issue. Although human capital is excluded from the analysis for the reasons outlined above, in principle, net investment in human capital should be an important contributor to future welfare. However, the negative effects of including education spending in the analysis of saving and future welfare in Ferreira and Vincent (2005) and Ferreira and others (2003) may simply be another manifestation of the small or negative growth impact of public education spending in developing countries analyzed by Pritchett (1996). In addition, for some countries, the exclusion of natural resources such as diamonds and fish may be a significant omission.

Exogenous shocks may present problems for testing the theory of saving and social welfare. The period under analysis in this chapter includes, in the early and least heavily discounted stages, the second oil shock in 1979 and a steep worldwide recession in 1981. However, Ferreira and others (2003) do not find any significant effects of exchange rate shocks in their analysis of the theory.

It should be noted that the theory being tested is particularly stringent, since it implies that measuring positive or negative saving *at a point in time* leads to future welfare being higher or lower than current welfare over some interval of time. In the real world, a positive exogenous shock (such as an improvement in the terms of trade) in the year immediately following the time when saving turned negative could easily swamp the effect of negative saving, and conversely for positive saving and negative shocks.

Turning to the results of the analysis, we find that the various saving measures are poor at signaling future changes in welfare in developed countries, similar to what Ferreira and Vincent (2005) and Ferreira and others (2003) find. This probably reflects factors other than capital accumulation being key for the growth performance of these economies: in particular, technological innovation, learning by doing, creation of institutional capital, and so on.

For all countries combined, we find that both net and Malthusian saving fit the theory poorly. The significantly low coefficients on Malthusian saving suggest that this measure overstates the effects of population growth on wealth accumulation per capita. Gross and genuine saving perform well, with estimated coefficients not being significantly different from the predicted values and with lower probabilities of rejecting a linear relationship between dependent and independent variables than for other measures. Genuine saving performs better than gross saving in terms of goodness of fit.

In terms of the more qualitative question of false positives and negatives, genuine saving provides, on average, a lower false-positive ratio than gross saving (22 percent of countries with positive genuine saving at a point in time actually experienced welfare declines, compared with 29 percent of countries with positive gross saving). Conversely, on average, negative genuine saving falsely signaled future welfare decreases in 38 percent of cases.

The bottom line is that genuine saving, excluding adjustments for population growth and education expenditure, is a good predictor of changes in future welfare as measured by consumption per capita. This result does not hold for high-income countries as a group, where factors other than simple asset accumulation are clearly driving future welfare. For developing countries the processes of accumulating produced assets and depleting natural resources clearly do influence their prospects for welfare.

Endnotes

1. While *Malthusian saving* is not a standard textbook saving measure, the name is useful and evocative for the purposes of this chapter.

2. Ferreira and others (2003) use estimated figures for consumption of fixed capital derived from the perpetual inventory model used to estimate total stocks of produced capital. Inspection of these figures reveals a fairly large number of anomalous estimates.

3. From 1970 to 1975 there are fewer than 40 countries with the necessary data, and these are primarily developed countries.

4. This is clearly a rather ad hoc test, but one that policy makers may care about.