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HOW TO USE THE SOUND INVESTMENT INDICATOR TO MEASURE SUSTAINABLE DEVELOPMENT IN THE FACE OF POPULATION AND TECHNOLOGICAL CHANGE

*by*

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# **Title**: How to Use the Sound Investment Indicator to Measure Sustainable Development in the Face of Population and Technological Change

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# Abstract

This paper presents an alternative to measure sustainability in economic terms that considers a growing population and rising technological level. This alternative measure of sustainability is known as the Sound Investment (SI) indicator (Saplaco et al., 2006). The paper includes what data to gather for employing SI, the computation process, how to interpret the results and the accompanying specifications to properly use the indicator in policy development and/or implementation on sustainability.


# Introduction

Currently, the available economic sustainability indicators are the Genuine Savings (GS) indicator and Green Net National Product (GNNP) (Mulalic and Olsen, 2004; Neumayer, 2004; Pearce and Warford, 1993; Solow, 1993; Tamai, 2000; and UM, 2001. However, these indicators operate under the assumption that population and technology are constant (Pearce and Atkinson, 1993). This limitation is addressed by SI, an economic indicator of sustainability, which allows the interaction of natural capital with changing population and technology (Saplaco et al., 2006). Using weak sustainability (Daly, 1990; Norton and Toman; 1997 and Tamai, 2000) in the Solow growth model (Solow, 1956; and Swan, 1956), the indicator uses the idea that the total capital stock, composed of man-made and natural capital substitutable for each other, must be non-decreasing through time in depreciation (Solow, 1993; Gutès, 1996; Ayres et al., 1998; and Tamai, 2000), population growth and technological advancement (Saplaco et al., 2006).

SI advocates a level of investment that matches population increase and technological advancement on top of depreciation for total capital. The indicator implies that for the growth and development of a country to be sustainable, the investment on man-made capital, at the very least, should match not only the combined depreciation of both man-made and natural capital, but also the increase in man-made and natural capital stock needed to maintain a growing population that utilizes advancing technology. This additional investment requirement arises because higher population and technological growth rates require higher levels of investment for sustainability (Saplaco et al., 2006).

# The indicator

SI is given by the following equation[1]:

$$SI \geq 0 \leftrightarrow S \geq \left[(n+g)K_T + \delta_M K_M + \delta_N K_N\right]. \quad (1)$$

where $S$ is gross savings, $n$ and $g$ are the exogenous growth rates of labor and technology, $K_T$, $K_M$ and $K_N$ are total, man-made and natural capital, respectively, and $\delta_M$ and $\delta_N$ are man-made and natural capital depreciation rates, respectively (Saplaco et al., 2006).

## Sustainability rule

Using Equation (1) and supplementing weak sustainability with population and technological change, an economy is sustainable if it invests ($S$) more than the amount of total capital needed by a growing quantity of effective labor ($(n+g)K_T$), over and above the combined depreciation on man-made and natural capital ($\delta_M K_M + \delta_N K_N$). Dividing through Equation (1) with $Y$ then expresses SI as a percentage of income:

$$SI \geq 0 \leftrightarrow \frac{S}{Y} \geq \left[\frac{(n+g)K_T}{Y} + \frac{\delta_M K_M}{Y} + \frac{\delta_N K_N}{Y}\right], \quad (2)$$

which conveniently measures deviation from borderline sustainability (Saplaco et al., 2006).

[1] The detailed derivation of SI is available upon request from the corresponding author.

# Description

SI may be intuitively thought of as the amount of compensation from current generations to future generations in terms of investment that accounts for population growth and technical change. Continuous positive values of the indicator mean that investment is greater than the total requirement to keep overall capital intact for a growing population utilizing advancing technology. Consequently, sustained negative investment would imply that the economy is on an unsustainable path and thus has continually declining welfare. Table 1 summarizes the different values of SI and their corresponding meanings (Saplaco et al., 2006).

Table 1. Explaining the Sound Investment indicator

| *VALUE* | *CONCLUSION* | *INTERPRETATION* | *IMPLICATION* |
|---|---|---|---|
| $SI < 0$ | unsustainable | the economy is not saving enough to sustain its income | as $SI \to -\infty$, greater effort is needed to get back to sustainable income |
| $SI = 0$ | marginally sustainable | the economy is saving just enough to sustain its income | current savings must be maintained or improved to continue being sustainable relative to national income |
| $SI > 0$ | sustainable | the economy is saving more than enough to sustain its income | as $SI \to \infty$, greater effort is being made to increase income beyond what is necessary to be sustainable |

# Sustainability implications

Accounting for population and technological change through SI provides clear implications towards sustainability. That is, a higher population growth rate $n$ requires a higher level of investment for income to be sustainable. Likewise, a higher rate of technological advancement $g$ means a higher level of investment is necessary for sustainability (Saplaco et al. 2006).

Thus, for a given level of technical progress and efficient levels of natural resource exploitation, sustainability could be achieved with the combined low depreciation on $K_M$ and $K_N$, high rates of investment, and low population growth (Saplaco et al. 2006):

$$SI \rightarrow +\infty \leftrightarrow \uparrow S \rightarrow \left[ \downarrow \delta_M K_M + \downarrow \delta_N K_N + \downarrow nK_T + \bar{g} K_T \right], \qquad (3)$$

## Necessary data

Computing for SI requires the use of time-series data. These include traditional national economic accounts (national income/output, gross savings, depreciation of man-made capital, and man-made capital stock); environmental economic accounts (depreciation of natural capital and natural capital stock); social accounts (population growth rate); and data on technological progress (technology growth rate).

# Sample computation

The sustainability of Philippine development in terms of its investment on man-made capital can be evaluated using SI with Philippine data.

## Data sources

### Traditional socio-economic accounts and technical data

Traditional national accounts are available from the Bangko Sentral ng Pilipinas (BSP) Online Statistics (www.bsp.gov.ph/statistics/overview.asp). The indicators used can be obtained from the series, “Selected Philippine Economic Indicators: Annual (2003 Yearbook)”. Likewise, Consumer Price Index (CPI) data, which are used for unifying prices in the computation, are also available from the aforementioned series. Social accounts are acquired from the National

Statistical Coordination Board (NSCB) Online Statistics (www.nscb.gov.ph). Data on population growth rate will make use of the "Population" series under Social Statistics.

Data on technological progress can be obtained from Mankiw et al. (1992). The authors assumed that the annual growth of technology was 2% and they argued that this figure or number was country-independent. This sample computation used the same figure as Mankiw et al.'s.

## Natural capital data

Environmental accounts are obtained from the National Statistical Coordination Board (NSCB) publication of the agency's Philippine Economic-Environmental & Natural Resources Accounting (PEENRA) unit, the Philippine Asset Accounts (PAA): Forest, Land/Soil, Fishery, Mineral and Water Resources (NSCB-PEENRA, 2000). The economic accounts on natural capital depreciation and stock are aggregated (summed) from the depletion, degradation, extraction and stock (monetary) estimates of the PEENRA only for forest, land/soil, mineral, and water resources. This is due to the unavailability of data on fishery stock in the accounts[2]. Table 2 presents the organization of the variables and data used in the sample computation, while Tables 3 and 4 give the final data set obtained from PAA for natural capital stock and depreciation, respectively.

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[2] See Appendix F, p. 127, of Saplaco et al., 2006 for a detailed explanation of the natural capital data source.

Table 2. Data Source Matrix

| *VARIABLE*[a] | *REQUIRED DATA* | *DATA SOURCE* | | *ENTRY IN DATA SOURCE (UNIT) [SERIES]* |
|---|---|---|---|---|
| $Y$ | national income/output | traditional national accounts | BSP[b] | Gross Domestic Product (million PHP, 1985) [1983-1993] |
| $S$ | gross savings | traditional national accounts | BSP | Net Savings (million PHP, nominal) [1983-1993] |
| $\delta_m K_m$ | depreciation of man-made capital | traditional national accounts | BSP | Depreciation (million PHP, nominal) [1983-1993] |
| $K_m$ | man-made capital stock | traditional national accounts | BSP | Gross Domestic Capital Formation (million PHP, nominal) [1983-1993] |
| $\delta_n K_n$ | depreciation of natural capital | environmental accounts | NSCB[c]-PEENRA[d] | *See Table 3* |
| $K_n$ | natural capital stock | environmental accounts | NSCB-PEENRA | *See Table 4* |
| $n$ | population growth rate | social accounts | NSCB | Average Annual Rate of Increase (percent) [1799-2000] |
| $g$ | technology growth rate | empirical study | Mankiw et al. (1992) | Advancement of Technology (percent) |

[a] The variables are as defined in the section, “The indicator”.

[b] Bangko Sentral ng Pilipinas

[c] National Statistical Coordination Board

[d] Philippine Economic-Environmental & Natural Resources Accounting

Table 3. Natural Capital Stock Data Compiled from the NSCB Philippine Asset Accounts (in 1985 Million PHP)

| *YEAR* | *FOREST*[a] *(A)* | *LAND/SOIL*[b] *(B)* | *MINERAL*[c] *(C)* | *WATER*[d] *(D)* | *NATURAL CAPITAL STOCK*[e] |
|---|---|---|---|---|---|
| 1988 | 452,426.53 | 376,798.34 | 73,609.88 | 806,900.93 | 1,709,735.68 |
| 1989 | 443,506.76 | 382,911.52 | 45,877.81 | 780,913.08 | 1,653,209.17 |
| 1990 | 383,278.23 | 399,479.21 | 31,083.16 | 654,392.84 | 1,468,233.44 |
| 1991 | 351,640.69 | 369,250.74 | 3,351.00 | 652,746.58 | 1,376,989.02 |
| 1992 | 369,141.21 | 368,237.02 | - | 693,687.37 | 1,431,065.60 |
| 1993 | 369,755.17 | 375,691.09 | 7,858.37 | 690,107.74 | 1,443,412.37 |

[a] CLOSING STOCK in Table 4. Monetary Valuation of the Closing Stock and Depletion of Forest Resources, in Current and Constant Prices, 1988-1994 (NSCB-PEENRA, 2000, p. 22), deflated from nominal to 1985 prices.

[b] CLOSING STOCK in Table 7. Monetary Estimate of Land Resources Devoted to Agricultural Uses, 1988-1993 (NSCB-PEENRA, 2000, p. 67), deflated from nominal to 1985 prices.

[c] TOTAL (SUM) of CLOSING STOCK entries in Appendix Table 2a. Gold Monetary Asset Account, Using the Net Price Method at 15% Interest Rate (NSCB-PEENRA, 2000, p. 153); Appendix Table 4a. Copper Monetary Asset Account, Using the Net Price Method at 15% Interest Rate (NSCB-PEENRA, 2000, pp. 125-156); and Appendix Table 6a. Chromite Monetary Asset Account, Using the Net Price Method at 15% Interest Rate (NSCB-PEENRA, 2000, p. 158), deflated from nominal to 1985 prices. No monetary asset was compiled for the year when the derived unit resource rent for NPM or the unit user cost for El Serafy (ESM) or User Cost Method (UCM) is negative or very negligible.

[d] TOTAL (SUM) of CLOSING STOCK entries in Table 7. Monetary Accounts: Groundwater in the Philippines, 1988-1994 (in Million Pesos) (NSCB-PEENRA, 2000, p. 153); and Table 8. Monetary Accounts: Surface Water in the Philippines, 1988-1993 (in Million Pesos) (NSCB-PEENRA, 2000, pp. 125-156), deflated from nominal to 1985 prices.

[e] Sum of A, B, C and D

CPI data from Bangko Sentral ng Pilipinas Online Statistics (www.bsp.gov.ph/statistics/overview.asp) were used for all deflations.

Table 4. Natural Capital Depreciation Data Compiled from the NSCB Philippine Asset Accounts (in 1985 Million PHP)

| *YEAR* | *FOREST DEPLETION*[a] *(A)* | *LAND/SOIL DEGRADATION*[b] *(B)* | *MINERAL EXTRACTION*[c] *(C)* | *WATER DEPLETION*[d] *(D)* | *NATURAL CAPITAL DEPRECIATION*[e] |
|---|---|---|---|---|---|
| 1988 | 21,301.50 | 1,195.82 | 1,137.18 | 47,282.61 | 70,917.10 |
| 1989 | 11,571.04 | 1,144.48 | 882.92 | 25,661.47 | 39,259.91 |
| 1990 | 7,163.41 | 1,251.74 | 465.38 | 74,575.70 | 83,456.23 |
| 1991 | 6,837.60 | 1,410.41 | 146.65 | 21,532.26 | 29,926.92 |
| 1992 | 290.16 | 1,125.29 | - | 7,235.34 | 8,650.79 |
| 1993 | 150.16 | 932.01 | 165.88 | 7,347.09 | 8,595.14 |

[a] DEPLETION in Table 4. Monetary Valuation of the Closing Stock and Depletion of Forest Resources, in Current and Constant Prices, 1988-1994 (NSCB-PEENRA, 2000, p. 22), deflated from nominal to 1985 prices.

[b] DEGRADATION in Table 7. Monetary Estimate of Land Resources Devoted to Agricultural Uses, 1988-1993 (NSCB-PEENRA, 2000, p. 67), deflated from nominal to 1985 prices.

[c] TOTAL (SUM) of EXTRACTION entries in Appendix Table 2a. Gold Monetary Asset Account, Using the Net Price Method at 15% Interest Rate (NSCB-PEENRA, 2000, p. 153); Appendix Table 4a. Copper Monetary Asset Account, Using the Net Price Method at 15% Interest Rate (NSCB-PEENRA, 2000, pp. 125-156); and Appendix Table 6a. Chromite Monetary Asset Account, Using the Net Price Method at 15% Interest Rate (NSCB-PEENRA, 2000, p. 158), deflated from nominal to 1985 prices. No monetary asset was compiled for the year when the derived unit resource rent for NPM or the unit user cost for El Serafy (ESM) or User Cost Method (UCM) is negative or very negligible.

[d] TOTAL (SUM) of DEPLETION entries in Table 7. Monetary Accounts: Groundwater in the Philippines, 1988-1994 (in Million Pesos) (NSCB-PEENRA, 2000, p. 153); and Table 8. Monetary Accounts: Surface Water in the Philippines, 1988-1993 (in Million Pesos) (NSCB-PEENRA, 2000, pp. 125-156), deflated from nominal to 1985 prices.

[e] Sum of A, B, C and D

CPI data from Bangko Sentral ng Pilipinas Online Statistics (www.bsp.gov.ph/statistics/overview.asp) were used for all deflations.

# Calculating SI

For the year 1993[3], the gross savings $S$ of the Philippines was PHP 61,151,180,931.74, national income $Y$ was PHP 734,160,000,000.00, depreciation of man-made capital $\delta_m K_m$ was

[3] Values presented have all been deflated to 1985 prices.

PHP 65,858,775,731.31, man-made capital stock $K_m$ was PHP 176,989,046.59, depreciation of natural capital $\delta_n K_n$ was PHP 8,595,138,373.81, natural capital stock $K_n$ was PHP 1,443,412,365,659.37, population growth rate *n* was 2.34% and technology growth *g* was 2%. Thus, Philippine SI for 1993 can be computed as follows:

$$\begin{aligned}
SI &= \frac{S}{Y} - \left[\frac{(n+g)K_T}{Y} + \frac{\delta_M K_M}{Y} + \frac{\delta_N K_N}{Y}\right] \\
&= \frac{S}{Y} - \frac{(n+g)K_T}{Y} - \frac{\delta_M K_M}{Y} - \frac{\delta_N K_N}{Y} \\
&= \frac{61{,}151{,}180{,}931.74}{734{,}156{,}000{,}000.00} \\
&\quad - \frac{(0.02335 + 0.02)(176{,}989{,}046.59 + 1{,}443{,}412{,}365{,}659.37)}{734{,}156{,}000{,}000.00}, \\
&\quad - \frac{65{,}858{,}775{,}731.31}{734{,}156{,}000{,}000.00} - \frac{8{,}595{,}138{,}373.81}{734{,}156{,}000{,}000.00} \\
&= -0.103359956 \\
&\approx -10\%
\end{aligned} \tag{4}$$

It can be seen that 1993 Philippine SI evaluated to –10%, indicating that investment relative to national output fell 10% short of sustainability. This value of SI deems the national income unsustainable at its corresponding level of investment when man-made and natural capital depreciation, population growth and technical progress come into play. As such, the economy needs to invest an additional amount equivalent to 10% of its national income that year in order to get back to a sustainable path of development.

# Policy implications

The general policy implication of SI is that for a country's growth and development to be sustainable, the amount of output that must be invested on man-made capital stock, at the very least, should match not only the combined depreciation of both man-made and natural capital, but also the increasing amount of man-made and natural capital stock needed by a growing population utilizing advancing technology. This is due to the higher population and technological growth rates requiring a higher level of investment for income to be sustainable.

Specifically, for a given level of technological progress and efficient levels of natural resource exploitation, sustainability could be achieved with the combined low depreciation on man-made and natural capital, high rates of investment, and low population growth.

# Final note

SI is a practical measure of sustainable development derived by combining capital and growth theories. This suggested measure aims to help properly include the environment into economic analysis by considering not just natural resources, but its interaction with changing population and technology. Properly incorporating the environment into policy-making would help attain economic sustainability at the very least. For instance, negative values in SI from 1988-1993 for the Philippines (Saplaco et al., 2006) suggest that annual investment may not be enough to cover total capital depreciation.

As such, this endeavor hopes to contribute to the overall effort of achieving a more immediate and practical implementation of the grand concept of sustainable development.

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