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On the indicator of weak sustainability*

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Abstract—The indicator of weak sustainability was analyzed in this paper, and it was concluded that it can yield some useful insights of sustainability from some aspects. Some weaknesses of the indicator were pointed out, and the recommendations for its improvement were proposed.

Keywords: weak; sustainability; indicator.

1 Introduction

Since the World Commission on Environment and Development's report "Our Common Future" (1987), especially after the United Nations Conference on Environment and Development in 1992, the notion of sustainable development has been studied extensively and deeply. Sustainable development is the development that meets the needs of present without compromising the ability of future generations to meet them (World Commission on Environment and Development, 1987). It is becoming increasingly a desired goal of development and environmental management. There is an urgent need to elaborate the concept of sustainable development and translate the theory into practically usable concepts and guidelines. In the research field of sustainable development, an important topic is the measurement of sustainability. Some noticeable and inspiring progress has been made on it (Weterings, 1994; Pearce, 1993a; Kuik, 1991).

Sustainability is one of the key problems of development. It is almost viewed as a universally

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accepted policy objective. However, it is difficult to analyze sustainability. There exist many different definitions of sustainability (Pezzey, 1992; Brown, 1987). But there is little agreement on the precise meaning of sustainability. Sustainability roughly means the ability of ecosystems maintaining their productivity under the circumstances of disturbances.

Various authors have established a relationship between sustainability, defined as non - declining utility, and the underlying capital stock (Pearce, 1993a; Solow, 1986; Hartwick, 1977). Hartwick has proven that this corresponds to a requirement to invest the rents from non - renewable resource use. This requirement is known as Hartwick's rule. Solow has further shown that Hartwick's rule can be interpreted as a requirement to "keep capital intact", i. e. "constant capital rule". This constant capital rule is known as "weak sustainability" in the literature of sustainable development. Weak sustainability requires that we should pass on to the next generation an aggregate capital stock not less than the one that exists now, or the sum of the values of various forms of capital should be kept non - decreasing. Compensations for natural capital depletion would be investment in any other form of capital of equal values. Therefore weak sustainability means that the forms of capital are assumed to be substitutable for each other.

There exist some limits to substitution among various kinds of capital; e. g. some critical natural assets are essential to human survival. The loss of them, e. g. the biodiversity and the ozone layer, may threaten the primary life support functions of ecosystems. For this reason, a strong sustainability rule is needed, which requires that the critical natural capital be held non - decreasing within the more general constraint that aggregate capital stock be non - decreasing (Pearce, 1993a; Opschoor, 1992).

From a practical point of view, Weterings and Opschoor (Weterings, 1994) elaborate in detail the strong sustainability rule. For essential renewable resources this "strong" approach entails that: (1) the stock levels to be maintained must be high enough to safely ensure a sustainable offtake at the current level at least, and (2) the quality of the regenerative systems instrumental in regeneration processes must be maintained beyond safe minimum levels of environmental standards. Environmental pollution and waste would then be allowed only in so far as prudently assessed absorptive capacities are not surpassed. Non - renewable resources would be allowed to be exploited as long as proven reserves are sufficient to provide for consumption over a pre - determined minimum time span.

Based on the concept of weak sustainability, Pearce and Atkinson proposed an indicator of weak sustainability, and got some preliminary and interesting results from the application of the indicator to 18 countries (Pearce, 1993a; 1993b). For the convenience of analysis, here we call the indicator of weak sustainability as P - A's indicator.

2 P - A's indicator of weak sustainability

Pearce and Atkinson divided the total capital stock K into three categories: man - made or reproducible capital, denoted as K_M in the conventional sense of machines, buildings and roads etc. ; human capital - the stock of knowledge and skill - denoted by K_H; natural capital - extensive natural resources - denoted by K_N. According to the meaning of weak sustainability, they got

$$dK/dt = d(K_M + K_H + K_N)/dt = S(t) - \delta K(t)$$
$$= S(t) - \delta_M K_M(t) - \delta_H K_H(t) - \delta_N K_N(t) \geqslant 0, \qquad (1)$$

where $S(t)$, δ, δ_M, δ_H and δ_N are the gross savings respectively, depreciations on total capital stock, the man - made, the human and the natural rèsource capital.

Assuming $\delta_H = 0$, dropping time t and dividing trough by income Y, (1) becomes

$$S/Y - \delta_M K_M(t)/Y - \delta_N K_N(t)/Y \geqslant 0 \qquad (2)$$

Let

$$Z = S/Y - \delta_M K_M(t)/Y - \delta_N K_N(t)/Y \geqslant 0 \qquad (3)$$

Pearce and Atkinson named Z as the indicator of weak sustainability. And they concluded that the value of Z must be zero or positive to ensure sustainability.

Pearce and Atkinson calculated the P - A′s indicator for 18 countries. According to the calculation, Japan, Costa Rica, the Netherlands, former Czechoslovakia, Hungary, Poland, Germany (pre - unification), USA are sustainable, whose P - A′s indicator values are 17%, 15%, 14%, 13%, 11%, 9%, 8%, 2% respectively; Mexico and Philippines are of "knife - edge" or marginal sustainability, whose P - A′s indicator values are all zero; Papua New Guinea, Indonesia, Malawi, Nigeria, Ethiopia, Madagascar, Burkina Faso, Mali are unsustainable, whose P - A′s indicator values are −1%, −2%, −3%, −5%, −7%, −9%, −9%, −14% respectively.

3 Comments on weaknesses and improvement of P - A′s indicator

3. 1 In the practical application of P - A′s indicator, we should keep it in mind that it is an indicator of (weak) sustainability, not sustainable development. There is a close relationship between sustainability and sustainable development, but they are different. Sustainable development is the development objective, and sustainability is the integrative base or conditions for the objective′s realization. Moreover, the assumption is, that $Z \geqslant 0$ is a sufficient condition for sustainability, which may be false.

3. 2 P - A′s indicator reflects to some extent desire for intergenerational equity; it dose not address intragenerational equity. The intergenerational and the intragenerational equity are two related aspects of the equity principle of sustainable development. They are both important for sustainable development and should be considered simultaneously (Zhao, 1991). In fact, the other will become meaningless if one of them is neglected.

3. 3 When P - A′s indicator is applied into a subsystem of the global system (here indicating the world), it is only the measurement of the sustainability of the subsystem. That is to say the subsystem is viewed as closed, its effects on other systems are neglected or ignored. We should pay more attention, especially from the long - term point of view, to the relationship between the systems related for the analysis of sustainability (Opschoor, 1991).

3. 4 P - A′s indicator examines the increase or decrease of the total capital stock, not the capital

stock per capita. If the growth rate of population exceeds the one of the total capital stock, the total capital stock per capita will decrease, which obviously does not satisfy the principles of sustainable development. Therefore it is more rational for P - A's indicator to consider the total capital stock per capita instead of the total capital stock, which will promote the regulation of human population.

3. 5 In their paper, Pearce and Atkinson said there are two criteria, the sustainability for all time periods (t) and the sustainability to be fulfilled over a prespecified time horizon long - term. They realized the shortcoming of the first criterion and said that some deviation from the requirement to maintain capital intact over short periods should be allowed. And the second criterion, they said, implies

$$\Sigma_t Z(t) \geqslant 0 \quad . \tag{4}$$

It can be proven that the inequality (4) can not guarantee capital to remain intact; in some cases it will make the total capital stock decrease. For example, suppose the initial capital is $K(0)$, a three - year period is examined, the capital growth rates of the first, the second and the third year are 7. 5%, 3. 0%, and -10. 0%, i. e. $Z(1)=7.5\%$, $Z(2)=3.0\%$, $Z(3)=-10.0\%$ respectively. Then

$$\Sigma_t Z(t)=Z(1)+Z(2)+Z(3)=7.5\%+3.0\%-10.0\%=0.5\% \geqslant 0$$

but

$$K(1)=(1+7.5\%)K(0)$$
$$K(2)=(1+3.0\%)K(1)=(1+3.0\%)(1+7.5\%)K(0)$$
$$K(3)=(1-10\%)K(2)=(1-10\%)(1+3.0\%)(1+7.5\%)K(0)=0.996525K(0) < K(0)$$

i. e. the total capital stock decreased.

Therefore we need to find another way for the sustainability measurement of a system over a period of time.

3. 6 Amsberg (Amsberg, 1993) proposed the concept of sustainability "continuum", in which there are four kinds of sustainability, the sustainability of welfare, the sustainability of consumption, the sustainability of supplies and the sustainability of extraction.

The sustainability of welfare corresponds to the weakest sustainability constraint, which requires that all man - made and natural capital together be kept intact so that they can support a non - declining flow of welfare permanently. Welfare is the result of variety of consumption streams that are combined in a welfare or utility function. The sustainability of consumption corresponds to a fairly strong sustainability constraint, which requires that groups of production inputs that generate different consumption flows be held intact in order to support non - declining consumption streams separately.

Similarly, consumption flows are created through some production processes that combine various goods. The sustainability of supplies corresponds to an even stronger sustainability constraint, which requires that groups of resources that produce different supplies be kept intact so that they can provide non - declining supply streams separately. Finally, the strongest sustainability constraint would apply at the level of the sustainability of extraction, which would require that the stock of specific assets be held intact such that they can support non - declining extraction streams.

4 Conclusions

Facing the difficulties of measuring sustainability, Pearce and Atkinson proposed the P - A's indicator, which provides an important direction or method of sustainability measurement for us.

Although the weak sustainability rule is limited in its real world relevance, Pearce and Atkinson's research results show that it can yield some useful insights of sustainability into a system from some aspects.

With the improvement of P - A's indicator, it will become more practically useful. At the same time, we should pay more attention to the study of P - A's indicator method with Amsberg's continuum, which will make the indicator for measurement of sustainability change gradually from "weak" to practically "strong".

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