A Model of Choice between Current Consumption and Future Economic Growth

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This paper uses a newly proposed working definition of sustainability based upon the Rawlsian principle of justice to develop a simple aggregative model of growth. The model explores the issue of choice between current consumption and future economic growth through changes in capital stock. It is shown that sustainable growth limits the range of this choice, but does not determine it. The model used is only illustrative, but may be useful as a pointer for future research and comparison of sustainability modelling techniques.

1. Introduction

Modelling sustainability is an increasingly popular subject in the areas of economic development, environmental policy and economic research in general. This is a puzzling phenomenon, since until now, a consensus on a working definition of the concept of sustainability has not been achieved. With no proper working definition, theoretical modelling would certainly be difficult but more importantly meaningless, as the impact assessment of environmental actions would be indeterminate. Symptomatic of this lack of a clear definition is a 1989 United Nation's survey. It reveals that, in spite of their concern, in general governments were not sure what directions constitute environmentally sound development policies (United Nations). Without an unambiguous definition, sustainability risks becoming a transcendent term, reminiscent of "appropriate technology" or "environmental quality" which are rarely defined explicitly, very difficult to measure, and almost impossible to model adequately.

Recently, Arifa, Gan and Sanyal, using the Rawlsian principle, proposed a working definition for sustainability that is intended to resolve some of these indeterminacies. Using this working definition, it is now hoped that theoretical modelling of sustainability becomes increasingly worthwhile. As a first application, this paper proposes a simple aggregative model that employs this definition of sustainability to explore its implications on the issue of choice between current consumption and future economic growth. Section 2 below briefly examines the newly developed working definition of the concept by Arifa *et al.* Employing this definition, section 3 is devoted to a model of a social decision framework. The final section (4) concludes with a brief discussion of the limitations of the model.

2. Sustainability, a New Definition Based on the Rawlsian Principle of Justice (1971)

It is an extension of the 1988 Tietenberg sustainability criterion (p.599) which suggests that "...at a minimum, future generations should be left no worse off than current generations". This implies that, in order to ensure sustainability, the actions of current generations in using resources should not reduce the standards of living of future generations below that of the current generation. As will be shown below, this condition has been retained by Arifa *et al.*, in their definition of sustainability.

The definition assumes that the current period of the economy has inherited a stock of material capital, K, and renewable environmental capital, E, from the last period. The production conditions are assumed to be characterised by:

$$(1) \qquad y = \min\left(\frac{K}{v_1}, \frac{E}{v_2}\right)$$

where y is the material production during the period. This specification implies that the production function has fixed-proportions. The operator "min" means that y is given by the smaller of the two values in parentheses. Therefore, if K/v_1 is less than E/v_2; then y would be equal to K/v_1, implying that $v_1 = K/y$. Otherwise, y would be equal to E/v_2, implying that $v_2 = E/y$. This would mean that v_1 and v_2 are the "capital output ratios" of aggregate output with respect to material and environmental capital stocks.

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This formulation does not allow for any substitution between the two factors of production; i.e., the two types of capital can become a bottleneck in production. The authors treat the two components of capital as non-substitutes simply to highlight the issue of sustainability. They argue that even though the two types of stocks are substitutable in a limited manner in reality, the problem of sustainable growth basically arises because of poor substitutability of the two. In fact, if it were possible to convert man-made capital completely into environmental stock at a future date, the problem of sustainability would disappear.

The authors also assume that production y entails W amount of waste generation; and that wy amount of current resources are required to treat and dispose of this waste. The society is faced with a choice of y in the range of 0 to the upper limit given by (1). If g is the growth rate over the last period's production y_{-1}, then $y = y_{-1}(1+g)$. This growth rate would be defined by the choice of y. Depending on the allocation of current product *y* among consumption, investments and waste disposal activities, the same growth rate *g* can leave different amounts of stocks and waste levels for the next period. Under these assumptions, sustainable growth would necessarily have to be defined by reference to the growth rate as well as the associated allocation of output. If i denotes investment in material capital, r in environmental capital and d the expenditure on waste disposal out of current production y, then a programme (g, i, r, d) is called sustainable by Arifa *et al.*, if it would leave:

(i) for the next period a material capital and environmental capital stock that, in view of Equation (1), make it possible to have a growth rate *g*; and

(ii) no more stock of waste than the period began with.

This definition needs some explanation. Welfare comparisons for different generations are generally done by contrasting their consumption levels. However, present generations can not pre-empt the choice of future generations except in a deterministic central planning model. It is for this reason that the authors decided to impose the rule that future generations should be left with enough stocks so that they can increase their total production at a rate no less than the present generation's. The allocation of this product between consumption and investment is a prerogative left to the future generations. Imposing this rule causes growth rates of successive generations, rather than their consumptions, being interlinked through available resource considerations. This also eliminates the usual indeterminacy characterizing inter-temporal choice models resulting from the inability to compare utilities across generations on a common scale.

3. A Proposed Model for Sustainable Development

The newly proposed definition of sustainability outlined above is used here in a model illustrating a relationship between growth rate and consumption. This relation restricts the choice of consumption and growth rate as compared to an economy without concern for sustainability. Properties and implications of this restriction are briefly discussed. It should also be mentioned that while a sustainable program restricts the possible growth rate and consumption choices, these choices are not determined uniquely by the program. So even after enforcing sustainability, there is room for choice of growth rates for the society.

Examining the characteristics of a sustainable programme (g, i, r, d) as defined by Arifa *et al.*, condition (i) in the definition implies:

$$(2) \quad \left(\frac{K+i}{v_1}\right) \geq y\,(1+g) = y_{-1}\,(1+g)^2$$

and

$$(3) \quad \left(\frac{E+r}{v_2}\right) \geq y\,(1+g) = y_{-1}\,(1+g)^2$$

The above two conditions show that a higher growth rate g, to be sustainable, requires larger investments i and r, leaving a smaller output for current consumption. Re-arranging (2) and (3) by solving for i and r implies:

$$(4) \quad i \geq v_1\, y_{-1}\,(1+g)^2 - K$$

and

$$(5) \quad r \geq v_2\, y_{-1}\,(1+g)^2 - E$$

On the other hand, condition (ii) of the same definition implies:

$$(6) \quad d \geq wy = wy_{-1}\,(1+g)$$

If c denotes current consumption, then the national accounts identity might be written as:

$$(7) \quad c = y - i - r - wy$$

Treating (4), (5), and (6) as equations, and substituting i from (4), r from (5), and wy from (6), into equation (7), it would be possible to derive the maximum possible consumption for any sustainable growth rate g. Equation (7) could then be expressed as:

$$(8) \quad c = y_{-1}(1+g) - v_1 y_{-1}(1+g)^2 - v_2 y_{-1}(1+g)^2 - wy_{-1}(1+g) + K + E$$

Equation (8) summarises the possibilities for consumption for the present period. Since y_{-1}, v_1, v_2, w, K and E are all givens, it describes current consumption as a function of different growth rates if the programme is sustainable according to the definition above.

As opposed to (8), an unrestricted relation between c and g will be given by the following:

$$(9) \quad c = y_{-1}(1+g) - i - r - d$$

where i, r and d are unrestricted choice variables. Clearly for any g, the maximum possible c on (9) will be higher than on (8).

Equation (8) is a quadratic relation. But by restricting g in the meaningful range g = 0 to $g = g_{MAX}$ where g_{MAX} is the maximum sustainable growth rate, it can be seen that dc/dg is negative throughout that range if v_1 and v_2 are greater and w smaller than unity. Both are valid assumptions under real situations.

Equation (8) can then be seen as a trade off between consumption and growth rate, that the society has to be conscious of in a choice about the combination (c, g). Thus sustainability as such does not exhaust the possibility of choice between current consumption and growth rate, but limits the choice compared to an unrestricted growth path.

The choice between c and g can be closed in a variety of ways. First of all the government, having imposed a set of physical, fiscal and regulatory price-and-fine schemes in the system, may withdraw from the economy. The choice then is determined by capital market considerations under these given restrictions. Secondly, it may be closed purely by *ad hoc* choice reflecting a political decision or compulsion.

Thirdly, it may also be closed by some macroeconomic policy considerations like employment etc.... For example, if labour force is growing at the natural rate n, and if $0 \; n \; g_{MAX}$, then n can be looked upon as a growth rate that maintains a steady rate of (un)employment of the labour force. It can be easily checked that if n is sustained with supporting i, r and wy programmes, then consumption also grows at the rate n. This can be called a steady rate of sustainable growth as long as inequalities (4), (5), and (6) are maintained every period.

Finally the choice may be effected by using a political decision function. The choice between current consumption and growth often presents itself as a political decision problem for the government. While current consumption has immediate political spin off, the growth rate is important for a government that is concerned about its whole term and looks beyond it. The consumption level of a composite set of goods and services at the current period (c_t) is the first argument of the decision function. The second argument is the rate of growth of the economy ($g_{t,t+1}$). From the government's view point both variables are important. The decision function will provide a quantitative statement of the relative importance of these two variables. For illustration, we will use a Cobb-Douglas specification for the decision function:

$$(10) \quad D_t = a \ln(c_t) + (1-a)\ln(g_{t,t+1})$$

where D is a decision variable to be maximised, and a is a parameter of the function. The functional form (10) is a monotonic transformation of the more usual Cobb-Douglas specification.

But economic compulsions create a trade off between the two, so that a higher growth target will depress current consumption. The trade off on a sustainable trajectory is shown by equation (8). The decision consists of maximising (10) under the restriction (8).

Maximise: $\quad D_0 = a \ln(c_0) + (1 - a)\ln(g_{0,1})$

Constraint: $\quad c_0 = y_0 - v_1 y_0(1 + g_{0,1}) - v_2 y_0(1 + g_{0,1}) - wy_0 + K + E$

We have assigned t=0 to the current period and t+1 = 1 to next period to simplify our notations.

Deriving the first order and second order conditions for this constrained maximisation problem, the solutions for the optimal c_0 and $g_{0,1}$ are:

$$c^* = a\,(1 - w)\,K / v_1$$

$$= a\,(1 - w)\,E / v_2$$

and

$$g^* = \frac{(1-a)\;(1-w)}{(v_1 + v_2)}$$

Alternative values of a can be used to find out their implications for consumption and growth rate. Such exercises may be useful, because the solution (c , g) usually determines other important variables for the system, eg government revenue, components of government expenditure and employment. By parametric variation of the decision function, the government can evaluate the economic implication of its own alternative political choices.

4. Summary and Suggestions for Future Improvements

In summary, the growth model developed above uses a working definition of the concept of sustainability inspired by the Rawlsian principle of justice . It suggests a working rule for the concept based on material and environmental stocks. It observes the restriction that future generations should be left with enough of these stocks enabling them to increase income at a rate no less than the present one. But the allocation of theses stocks among consumption and investment needs is left to future generations. Not surprisingly, and like in most inter-temporal choice models, the solution shows a trade-off between current consumption and the future growth rate. However, in this case, the indeterminacy characterizing inter-temporal choice models resulting from inadequate means of comparing across-generation utilities is eliminated.

We realize that this model is far from being comprehensive. One of its limitations arises from its one commodity nature, which forces some important issues out of consideration. Also, the model does not allow for technological variations across generations. In expanding the model to allow for across-generation technological variations, progress in relevant technologies and research and development activities should be incorporated. Also, with respect to technology, the fact that improvements tend to exert an asymmetrical effect on environmental amenities and consumption, as argued by Krutilla and Fisher (Pearce and Turner, 1990), should be taken into account in future modelling. Another important shortcoming of this model is that it does not address issues of the type specifying ecological safe minimum standards and permanent ecosystem damage. In short, the model proposed above, which is the first to utilize the Arifa *et al.,* working definition of sustainability, ignores many details. But it is hoped that future research on sustainability modelling techniques will address the missing details.

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