THE ENVIRONMENT AND THE MACROECONOMY: SOME CONCEPTUAL CONSIDERATIONS WITHIN A KEYNESIAN FRAMEWORK

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ABSTRACT This paper illustrates how the environment can be included in a macroeconomic framework. For illustrative purposes a Keynesian framework is considered. The application of a modified Keynesian framework illustrates the choice of economic instruments such as taxes and interest rates to be based not merely on the equilibria between national income and expenditure, but also on the role of the environment in attaining such equilibria. Central to the framework considered are the concepts of "the assimilative capacity of the environment", and an "environmental cost function".

1. INTRODUCTION

Given the growing inventory of environmental problems across the world, sustainability needs to be the dominant policy goal in all economies. Hence, as illustrated in Costanza and Daly (1987) and Costanza (1991), policy formulation requires an explicit recognition of the linkages that prevail between the natural environment and the economy. One of the shortcomings of environmental economics to fully explore these linkages has been the preoccupation with the microeconomic analyses of environmental problems (Daly 1991). This paper represents an attempt to off-set this shortcoming, at least in a small way, by exploring the means of integrating the environment into the macroeconomic analyses of policy formulation.

The basis for introducing the environment into macroeconomic analyses is provided in environmental accounting (Ahmad, El Serafy and Lutz, 1990, and Peskin, 1989). Two items are central to the methods of environmental accounting:

(i) the acknowledgement that the environment is an integral component of any economic system, and
(ii) the inclusion of the environment's contribution to the economy in the statement of national income accounts.

The object of this paper is to illustrate how the central principles and concepts of environmental accounting can be included in a Keynesian framework of output and employment growth. Conceptually, such a modification is a simple extension of the modified statement of income accounts. Yet, the literature does not appear to deal with this aspect. Further, as illustrated below, the application of the modified Keynesian framework would permit the choice of economic instruments such as taxes, interest rates and money supply to be based not merely on the equilibria between national income and expenditure but also on the role of the environment in attaining such equilibria. The framework would also enable the illustration of the limits that are imposed on economic growth by the environment. As argued below, any relief from these limits to continue economic growth would be feasible only by developing technologies that are environmentally efficient, or to coin a phrase, "environment saving" technologies.

The paper is structured as follows. The framework proposed here rests on two concepts, namely the assimilative capacity of the environment and environmental costs. These concepts are explained in the next section in terms of the linkages that prevail between the environment and the economy. The third section deals with the conceptualisation of possible relationships between environmental costs and national income. These relationships are then used in the adaptation of a simple Keynesian framework to internalise the environmental costs. This internalisation has important policy implications which are then considered, and these include the important role the natural environment can play in permitting an economy to recover from a period of recession and unemployment.

2. ASSIMILATIVE CAPACITY AND ENVIRONMENTAL COSTS

In any economy, the environment provides three basic inter-related functions. It provides raw materials such as air, water, minerals and other necessities to all sectors of the economy. It acts as a receptacle for the wastes that are generated by the various players in the economy. The environment also provides amenities, such as facilities for recreation, beautiful scenery and unspoilt beaches.

The inter-relationships that prevail between the three functions of the environment have been explained in terms of the concept of the assimilative capacity of the environment (Pearce 1978). Suppose that an economy begins its operations in a pristine environment. The wastes and by-products of the initial set of economic activities can be assimilated by the environment, without the environment losing any of its characteristics. For example, micro-organisms can decompose wastes, whilst plants can absorb carbon gases. This is referred to as the *assimilative ability* of the environment. But, there is only a certain limit up to which the environment can display this ability. This limit is referred to as the *assimilative capacity of the environment*. When the dumping of wastes is intense and continuous, the assimilative capacity is exceeded, and the environment loses its assimilative ability, and is unable to fulfil its functions as a waste receptacle. However, when this happens, the environment which is infested with toxic materials also ceases to be a source of raw material and amenities.

The concept of assimilative capacity is central to the principles of environmental accounting. At any given time, the natural environment, that is the collection of all natural endowments, can be regarded as a stock of capital. To distinguish this from the usually recognised forms of man-made capital (such as machines and buildings), the term "environmental capital" is often used. Like any form of capital, environmental capital generates a flow of services. These services are, in fact, the three types of inter-related functions that were indicated above. Further, should the assimilative capacity of the environment be left intact, these services would be generated indefinitely. However, the process of economic growth inevitably affects the assimilative capacity of the environment. As a result, society incurs four types of costs in order to maintain the assimilative capacity of its environment. These costs are as follows:

(1) *Costs involving production* - These are expenditures that are incurred by producers in order to maintain the services of the environment. They include the costs of complying with pollution control regulations and, in general, the costs of treating and disposing the wastes that are generated from production. Let these costs be denoted by e_p.

(2) *Costs involving current consumption* - These refer to expenditures that attempt to enhance the safety of consuming environmental services; for example water filters on taps and air filters on ventilation shafts. These could also include medical expenses due to illnesses induced by polluted environments. Let these costs be denoted by e_c.

(3) *Costs involving future consumption* - These costs arise from the depletion of the stocks of renewable and non-renewable resources and the imposition of costs on future generations by the non-availability of these resources. Let these costs (which are also referred to as user costs) be denoted by e_u.

(4) *Costs of restoring damaged environments* - These include expenditures such as the costs of detoxifying rivers that are infested with algal blooms and the costs of rehabilitating sites that have been mined. Let these costs be denoted by e_r.

The first three of the above costs are analogous to "variable costs", because they deal with the services of an environment which is functional; that is one that continues to provide a flow of services. Following Peskin (1989), these costs can be described as those that explain the depreciation of environmental capital. That is, for example, as air quality deteriorates, households and firms need to purchase more air filters, and may have to make these purchases more frequently as well. Following McInerney (1981), the user costs are consumption benefits which the future generations have to forego and can be explained within the framework of variable costs. The final cost, namely the cost of restoring damaged environments, is analogous to an investment in replacing depreciated capital. This is because it deals with an environment that has ceased to provide services.

In the current systems of national income accounting most of the above costs are included in net national product (NNP) on the premise that they represent some form of economic activity. The basic tenet of environmental accounting is that the above costs are true expenditures that are incurred in generating national output and hence should be subtracted from the value of NNP. No doubt, the inclusion of environmental costs in the value of final output overstates the performance of an economy and exacerbates the inefficiency of NNP as a measure of welfare. Hence, the proponents of environmental accounting suggest that the performance of an economy is better measured by NNP - $(e_p + e_c + e_u + e_r)$.

3. ENVIRONMENTAL COSTS AND NATIONAL INCOME

Let the four types of environmental costs that are incurred during a given accounting period be denoted by e. That is, $e = (e_p + e_c + e_u + e_r)$. Consider now the relationship between the e and national income (Y). It is reasonable to assume that increases in Y would prompt increases in e. However, increases in Y are feasible only up to a certain point. Any attempt to increase Y beyond this point could push e towards infinity. This is due to the loss of assimilative capacity and irreversible damages that would be inflicted on the environment during prolonged periods of growth. Such a conceptualisation for e places the environment in the category of non-renewable resources; for example, see Anderson (1985). Besides, the treatment of the environment as a non-renewable item is valid given that it is a complex system of resources and the ability to recoup the assimilative capacity from such a system is inevitably finite.

For reasons of simplicity and convenience assume that the relationship between e and Y, namely $e = g(Y)$, can be described as follows:

$$e = e_r + wY \qquad \text{for } 0 < Y \leq Y_h, \; w > 0 \tag{1}$$

and

$$e \to \infty \qquad \text{for } Y > Y_h \tag{2}$$

That is, during any accounting period, Y_h is the maximum limit to which output can be produced. This is a limit in terms of the assimilative capacity of the environment. Any attempt to increase income beyond Y_h results in irreversible environmental damage, and hence e tends to infinity as shown in (2). Further, the relationship between e and Y is assumed to be linear, and within the limit of Y_h, it is assumed following (1) above that the size of e is governed by the following factors:

(i) the extent of environmental restoration (e_r) that has to be done at the start of the period due to damaging output activity that had occurred during previous periods; (for example, in some cases, agricultural production cannot commence unless algal blooms have been removed and contaminated soils have been detoxified); and

(ii) the variable costs which are incurred during a period, and which increase at the rate of w for unit increases in Y.

w can be also regarded as the marginal rate of environmental degradation. That is, $w = \Delta e / \Delta Y$.

In terms of (1) and (2) above, four types of relationships between e and Y can be envisaged, and are illustrated in Figures 1 and 2. Each of these characterise the state of the environment in an economy, and permit the nomination of output targets as shown below. The 45^0 degree line in each of these figures defines the set of points where $e=Y$. In Figures 1a and 1b, economic activity is assumed to commence in a pristine environment. Hence, environmental restoration costs are absent and e does not emerge until after a certain amount of national income, say Y_i, has been generated. This is due to the assimilative capacity of the environment. That is, up to an income level of Y_i, any wastes that are generated can be assimilated by the environment without diminishing the functions of the environment. Increasing national income beyond Y_i results in an increase in e. However, as indicated, the assimilative capacity of the environment cannot be recouped beyond Y_h, due to e tending to infinity at this point. Hence, in Figure 1a, the feasible set of output targets

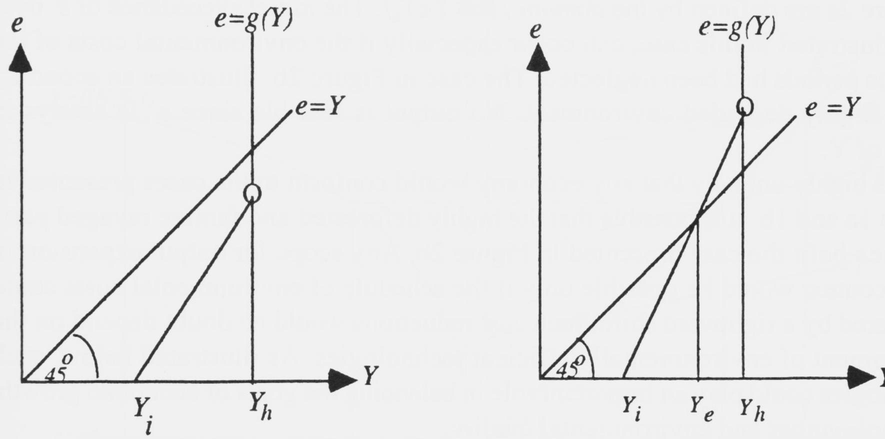

Fig.1a Fig.1b

Figure 1. Relationship Between Environmental Costs and National Income - Pristine Environment

are defined by the domain $\{0<Y \leq Y_h\}$. However, as illustrated in the next case (Figure 1b), the set of growth targets are confined to the domain $\{0<Y \leq Y_e\}$, because $e > Y$ for $(Y > Y_e)$. Some examples of how e can exceed Y are as follows. The costs of pollution and ill health can outweigh regional income from output should the region be highly polluted such as in the industrial belts of Eastern Europe; or the costs of correcting soil degradation can exceed agricultural income, if it is practised on marginal lands.

Figures 2a and 2b deal with an environment that has already degraded. Hence the value of e_r is positive at the start of the accounting period. For an economy displaying the features of Figure 2a, it would be irrational to set output targets over the domain $\{Y<Y_d\}$, since $e > Y$ over this domain. Hence the feasible output targets

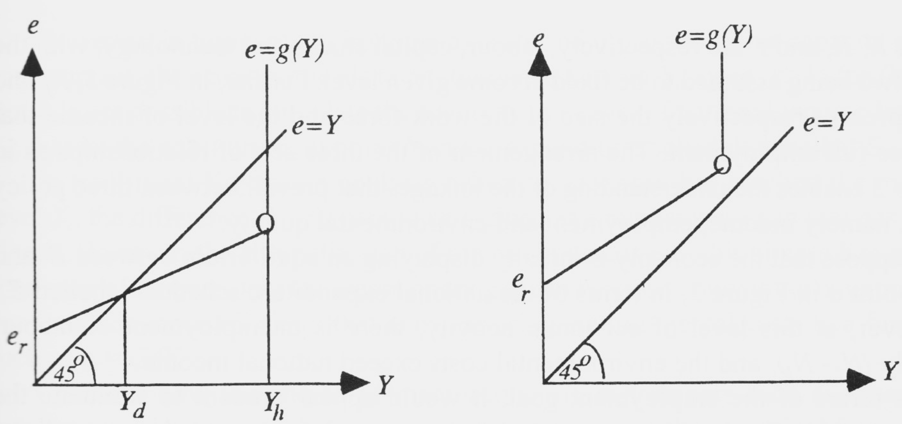

Fig.2a Fig.2b

Figure 2. Relationship Between Environmental Costs and National Income - Degraded Environment

in Figure 2a are defined by the *domain* $\{Yd<Y\leq Y_h\}$. The initial exceedance of e over Y, as illustrated in this case, can occur especially if the environmental costs of the previous periods had been neglected. The case in Figure 2b illustrates an economy with a highly degraded environment. No output is feasible since e is always in excess of Y.

It is highly unlikely that any economy would conform to the cases presented in Figures 1a and 1b. It is possible that the highly deforested and famine ravaged parts of Africa befit the case presented in Figure 2b. Any scope for output expansion in such a context would be possible only if the schedule of environmental costs could be lowered by a rightward shift. Such cost reductions would no doubt depend on the development of environmentally efficient technologies. As illustrated below, such technologies could play an important role in balancing the goals of economic growth, full employment and environmental quality.

4. THE ENVIRONMENTAL COSTS IN A KEYNESIAN FRAMEWORK

The relationship between e and Y can be introduced into a Keynesian framework as illustrated in Figure 3, and thereby permitting the joint recognition of income and employment along with the environment. The top right hand corner presents the traditional relationship between national expenditure *(E)* and national income *(Y)*. Note that E and Y are defined in terms of final goods and services and do not include any good or service that pertains to the environmental costs, namely e. In the lower right-hand corner, the relationship between e and Y is considered. For illustrative purposes, this relationship is assumed to be the case that was previously considered in Figure 2a. The relationship between output and employment, namely the usual production function, is presented in the top left-hand corner. Following usual practice, this production function is defined as:

$$Y = f(N, K, t) \tag{3}$$

where N, K, and t are respectively, labour, capital stocks and technology, with the latter two being assumed to be fixed at some given level. Further, in Figure 3, N_f and Y_f represent respectively the size of the work force and the level of income that ensures full employment. The arrangement of the three sets of relationships as in Figure 3 enables the understanding of the linkages that prevail between three policy goals, namely income, employment and environmental quality.

Suppose that the economy is initially displaying an equilibrium between E and Y at point a in Figure 3, in terms of the national expenditure schedule labelled E_l. However, at this level of economic activity, there is unemployment of labour, namely $(N_f - N_l)$, and the environmental costs exceed national income.

In terms of the employment goal, it would appear prudent to stimulate the economy (say by lowering taxes and interest rates) to prompt the expenditure schedule to move towards point c; that is, to the level of national income Y_f that guarantees full employment.

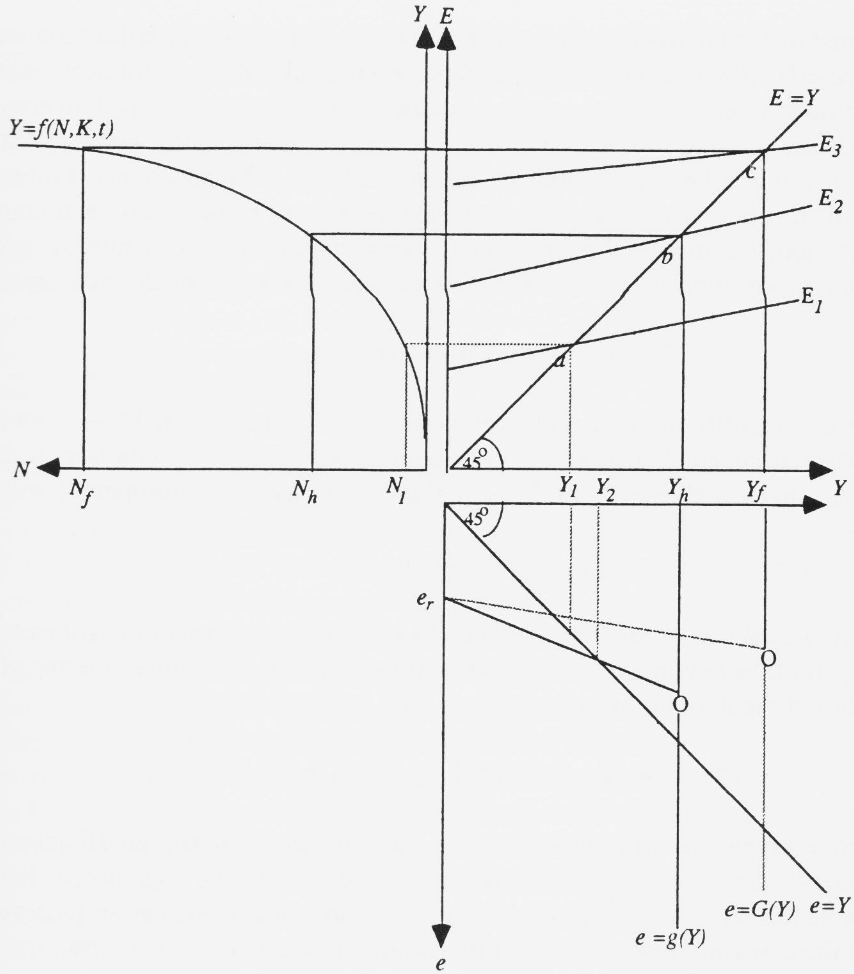

Figure 3. Internalising the Environment in a Keynesian Framework

However, in terms of environmental costs and the assimilative capacity of the environment, the economy needs to be stimulated beyond Y_2, since $(e>Y)$ for $(Y<Y_2)$. But it is not possible to stimulate the economy to a level of national income beyond Y_h; that is, the equilibrium at point *b* on the expenditure schedule labelled E_2.

In traditional Keynesian analysis, when an economy has reached the income level Y_h, the difference $(Y_f\text{-}Y_h)$ would be defined as a recessionary gap that has to be closed. However, the internalization of the environment into this simple Keynesian framework illustrates that the recessionary gap can be closed only if the environment can be made more efficient; that is by lowering environmental costs to a function such as $e = G(Y)$.

Consider now the choice of macroeconomic instruments such as taxes and interest rates in terms of the environmental costs within the analytical framework that has been presented in Figure 3. For example, consider the determination of the rate of income taxation in a closed economy. Suppose that such a tax is the only policy instrument, and that it should be set to achieve the level of income at the limit as defined by the environmental costs. That is, Y_h in Figure 3. Since the economy is assumed to be closed and income taxes represent the only policy instrument, national expenditure is defined in terms of consumption *(C),* Investment *(I)*, Government Expenditure *(G)* and Tax Revenue *(T)*. Further, for convenience, assume that the levels of I and G have been predetermined as I^* and G^* respectively. Following standard practice, by letting a, b, and t represent respectively autonomous consumption, the marginal propensity to consume and the mean rate of income taxation, the equilibrium level of national income (Y^*) would be defined as:

$$Y^* = (a + I^* + G^*) / 1 - (b - bt) \tag{4}$$

Should this equilibrium be denoted by point b in Figure 3, then $Y^* = Y_h$ and the value of environmental costs that have to be incurred to have this equilibrium is e_h. Further, using (1) above, Y_h could be defined in terms of environmental costs as follows:

$$Y_h = (e_h - e_r) / w \tag{5}$$

It is now possible, by equating (4) and (5) to define the magnitude of taxes that would permit the maximum level of national income that is feasible in terms of the assimilative capacity of the environment. That is:

$$t^* = [w\,(a + I^* + G^*)/b(e_h - e_r)] - 1/b + 1 \tag{6}$$

Hence given the information on the usual macroeconomic coefficients and parameters and the environmental costs that would be registered in the environmental accounts, it is possible to define an instrument such as an income tax so that the economy operates within the assimilative capacity of its environment. Note that the rate of taxation is influenced by w, e_r and e_h. It is clear that tax rate becomes more regressive as w increases, and the gap between e_h and e_r narrows. Since e_h is fixed and predetermined, $t^* \rightarrow \infty$, as $e_r \rightarrow e_h$. It is not difficult to envisage the expansion of the analysis illustrated above to include other instruments such as interest rates and money supply.

5. IMPLICATIONS OF THE MODIFIED KEYNESIAN ANALYSIS

The inability to alleviate the unemployment problem by pump priming an economy is usually ascribed to structural rigidities and market imperfections in the economy. For example, when labour unions set barriers to entry and the log of wage claims are prohibitive, the usual Keynesian incentives would not have the desired employment and output effects. However, the constraints on the realisation of economy wide outcomes are not confined to market and structural imperfections but include the environment as well. For example, if interest rates are lowered with the hope of stimulating the housing industry, and if environmental services to support such expansion have already been exhausted, then the incentives would have little effect. Anecdotal evidence in Australia suggest that the sluggish response of the

Table 1. Deforestation and Inflation in Selected Countries

Country	Annual Deforestation (1981-85) (square kilometres)	Average Inflation (1991)
Ghana	900	42.5
Zaire	5500	60.9
Peru	5400	233.9
Brazil	13800	284.3
Bolivia	2100	317.9
Argentina	1800	395.2
Nicaragua	2400	432.3

Source: World Bank (1992)

housing sector to the specific incentives that have been effected since 1991, are partly due to the limits imposed by environmental constraints. This is especially the case in major metropolitan areas. For example, the limited capacity of the Hawkesbury-Nepean river system is regarded as a significant constraint to urban expansion in outer Western regions of Sydney.

It is acknowledged that stimulating aggregate demand when an economy has reached its productive capacity can lead only to inflation. Hence, it follows that demand stimulation in the context of adverse environmental damage should result in inflation. Although the evidence is not conclusive, it is possible to argue that some Latin American and African countries display phenomenally high rates of inflation partly because of the degradation of their natural environment. Table 1 shows the positive association between deforestation and inflation in selected countries.

In the context of limiting environmental constraints, an economy can expand its output and employment only if it is capable of making its environment more efficient. The search for such efficiency warrants investments in technologies that would permit the environment to provide cost-effective services to the economy. These technologies can include innovations in fields such as molecular biology, biotechnology and environmental engineering; for example a cost-effective biotechnology technique to treat algal blooms or a technique in chemical engineering to treat sewage. Such innovations are capable of shifting the environmental cost function outwards, and thereby allow demand to expand. Hence when an economy has to be revived out of a recession, it is pertinent for policy makers to distract themselves from the usual mechanisms of pump priming the economy and consider incentives for investments in technologies that would render the natural environment more effective. The inventory of growing environmental problems across the world suggests that such a policy directive is relevant.

6. CONCLUSIONS

The simple conceptual framework considered above illustrates that restoring the environment and its assimilative capacity can be essential in recovering economies out of phases of economic recession and unemployment. Some economists, for example, Baumol *et al.* (1988) argue that whilst economic growth may bear some adverse effects on the environment, continued economic growth is essential, if not for anything else but at least saving the environment. Their contention is that economic growth would generate sufficient income that could be invested in ventures that could restore the environment. In terms of the framework considered above, such a notion is indeed valid, if the economy were operating at levels of income less than Y_d in Figure 3. However, as the income level approaches Y_h, the environment imposes a clear limit on the capacity of the economy to grow. As indicated, this limit can be alleviated only by developing an environmentally efficient technology.

The linear assumption for the environmental cost function renders the upper limit of national income as the desirable growth target. This is because, the maximum departure between national income and environmental costs occurs only at this level of income; that is, Y_h in Figure 3. Choosing an output target at the limit also implies that the economy could be on the brink of an environmental disaster, since a slight mismanagement could render the environment to be irreversibly damaged. However, if the relationship between e and Y were non-linear, then the growth target may not necessarily border the limit, and could be specified in terms of maximising the difference $(Y - e)$.

Finally, the applicability of this framework would no doubt depend on the widespread development of environmental accounts. Given that time series data on such costs are virtually absent, the estimation of these cost functions would inevitably depend on cross-sectional data and hence there is a need to develop environmental accounts at various regional and national levels.

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