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ENVIRONMENTAL AND SOCIAL DEGRADATION AS THE ENGINE OF ECONOMIC GROWTH

ABSTRACT: In this paper, a commonly owned resource (an environmental or social asset) and a private good are substitutes in consumption. The households can buy the private good on the market, while the resource is available for free. The resource is renewable, but its ability to regenerate declines with the level of aggregate production: each single firm producing the private good has only a negligible impact on the resource, but the impact caused by the entire population of firms is considerable. In the face of a decrease in the stock of the resource, households are induced to increase their participation to market activities in order to raise their income and buy more private goods. Hence, each household contributes to a further increase in aggregate production, thus causing additional damage to the resource' ability to regenerate and feeding the growth process. Given the presence of negative externalities, multiple equilibrium paths are possible. In this situation, social conventions may guide individuals to coordinate expectations and behavior toward a particular steady state: one can speculate that the dominance of cultural values favorable to a lifestyle based on a mix of high consumption and hard work leads the economy to converge on a Pareto-inferior steady-state.

KEY WORDS: Renewable resource, Defensive expenditure, Multiple equilibria, Coordination failure, Global indeterminacy.

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INTRODUCTION

In this paper, we illustrate a view on growth that is different from the dominant paradigm insisting that growth is fed by positive externalities, since we model growth as a process driven by the individuals' defensive reaction to the negative externalities generated in the course of the production process. Indeed, we introduce a renewable resource (an environmental or social asset) whose ability to regenerate declines with the level of aggregate production, in a situation where each single producer has no incentive to internalize the negative effect that it causes on the commonly owned resource. Given that the produced good enters individual welfare as a substitute for the renewable resource, households react to the depletion of this resource by increasing their participation to the labor market in order to raise their income and buy more private goods. Hence, each household contributes to a further increase in aggregate production, thus causing additional damage to the resource's ability to regenerate and feeding the growth process.

Given the presence of negative externalities, multiple equilibrium paths are possible, and the economy may converge on a long-run equilibrium that is Pareto-dominated by some other locally stable steady state. Indeed, there may be a coordination failure due to the self-fulfilling nature of rational expectations: if the individuals expect that others (do not) work hard, thus keeping high (low) the levels of production and private consumption, they do the same since they anticipate that the commonly owned resource will (not) be seriously damaged. As a result, expectations will be validated and the economy will follow an equilibrium path characterized by a relatively high (low) level of production and by a relatively low (high) level of environmental quality. Social conventions and cultural values may play an important role in coordinating the individual expectations and selecting the equilibrium that will be realized: on the basis of the model, one could speculate that in a society dominated by a hyper-consuming life-style and by a strong work ethic the level of market activities will be higher and the quality of the social assets will be lower than in a society in which the consumer attitude and the work ethic are weaker.

Legitimate interpretations of the mechanism outlined in the paper can be couched both in terms of environmental assets that are damaged by productive and consumption activities and in terms of institutional and cultural bases of modes of collective action that are undermined by the enlargement of the market. In both cases, individuals have to increasingly rely on privately produced goods in order to avoid a decline in their well-being.

The ideas underlying the paper have a long and interdisciplinary history behind them. A satisfactory survey of the contributions given to this history by anthropologists, sociologists, psychologists, philosophers, economic geographers, economic historians, as well as economists, and economists of development in particular, is obviously beyond the scope of this paper. However, among the twentieth-century economists who have helped to shape these ideas, mention should at least be made of Polanyi (1968), and Hirsch (1976). Indeed, their works have strengthened the view according to which economic development is both the effect and the cause of the erosion of traditional institutions and cultures, whose decline releases the energies that feed the growth process with its destructive power on such institutions.

The model presented here seeks to explore the explanatory and predictive potentialities of these ideas in a very simple way. [1] Its focus is on the determinants of work input and consumption patterns, and its main argument is that environmental and social degradation may play a role in changing work and consumption habits in a direction favorable to growth, in the sense of stimulating the participation to market activities and the demand for private consumption.

The model's implications and predictions are often complementary to those of current growth models. In other instances, it may help to shed light on stylized facts that modern growth theory has somehow overlooked.

We share with the literature on sustainable growth its concern for the impact that current economic activities can have on long-term growth performances and future well-being by depleting social and environmental assets. This literature, however, focuses on whether unbounded growth is possible in the presence of natural resources that are negatively affected by the growth process and not on the role of engine of growth played by the progressive degradation of these assets. In other words, this literature does not appear to be fully aware of how the declining endowment of free resources can boost economic growth.[2] In contrast, we focus precisely on how work attitudes and

[1] This paper is a part of a larger research project. The idea that growth can be treated as a process of substitution of free goods with costly ones first appeared in Bartolini (1993). The first model based on this idea was an evolutionary game that obtained similar results to those obtained in this paper (see Antoci and Bartolini, 1997). The fact that in the same structural circumstances the same results are obtained with both neoclassical and evolutionary choice mechanisms gives robustness to the idea that growth can be generated by negative externalities.

consumption habits become more favorable to growth as individuals have diminishing opportunities to receive well-being not transacted on the market.

The paper is organized as it follows. Section 1 discusses some of the points that motivate the model. In Section 2 we present the model. Section 3 studies the competitive equilibria within a single-period time horizon. The equilibrium paths along which a *laissez-faire* economy moves in the infinite horizon case are derived in Section 4. Section 5 analyzes some welfare implications of the market dynamics studied in the previous sections. Section 6 concludes.

1. MOTIVATIONS

The commercialization of land and leisure

In our model the core of the growth mechanism is a substitution process based on the destruction of non-market goods, in the sense that growth is fuelled by a diminution in free consumption[3] and by its substitution with costly ones. In other words, in our case growth is driven by its own destructive power. In an economy in which the well-being of those who maintained their purchasing power unchanged would deteriorate, individuals will be led to increase their efforts aimed at raising their real income.

The mechanism modeled in this paper is well known to the historians studying the period that prepared the way for the Industrial Revolution: the diminution in free consumption was a pre-condition of modern economic growth, stimulating that constant rise in income aspiration which induced the households

[2] The predominant opinion seems to be that negative externalities may weaken growth, and in this sense it has been hypothised that they have played a part in the recent decline of the growth rates of the advanced countries. This opinion strikes us as partially justified if it is related to mainly rural economies, where production relies largely on natural resources but not to industrial or post-industrial economies, where the principal function of the free resources is precisely their use as a repository for waste. There are cases of industrial sectors - for example textiles as regards water - that need high quality natural resources in certain manufacturing phases. But they seem unimportant, if compared with the use of the environment as a repository for waste. However, also in the poor countries, the decrease in production due to negative externalities (as, for example, the loss of arable land due to erosion and desertification, or the decline of fish stocks) does not decrease GNP if, as frequently happens, they affect non-market activities like individual and communal self-production. In this case, the reaction of the population affected may be urban migration, which increases the labor supply and may be the basis for the development of the manufacturing sector and services. So, even in the case of poor countries, in which negative externalities mainly concern the use of the environment as an input and not as a repository for waste, the effect of their detrimental impact is a rise in GNP, even though the increase in production is in part a statistical illusion due to the disappearance of non-market productive activities and their replacement by market ones. This effect can be treated with the model we presented in this paper.

[3] Henceforth the term free (or common) consumption will be used synonymously with free (or environmental) resource (or good).

to deploy their labor time (see Blanchard, 1994). Indeed, the commercialization of land and leisure, first experienced in north-western European nations, has to be considered a paradigmatic example of a process limiting the possibility of free consumption. The "enclosures" -- the process whereby the private property of land was extended in Britain -- broke up the communal institutions of land use and deprived vast numbers of the rural population of their means of subsistence, uprooting them from agricultural under-employment and forcing them into urbanization or vagabondage. As a parallel development, the commercialization of leisure contributed to undermine the position of the peasant community: in the attempt to maintain their status and related consumption pattern, the working population were forced to steadily increase their labor supply in order to earn more and buy the market goods needed to enjoy the leisure left to them.[4] In other words, this process of commercialization played a crucial role in that "Industrious Revolution" with important demand-side features which began in advance of the Industrial Revolution and "altered both the supply of marketed goods and labour and the demand for market-bought products" (de Vries, 1993, p. 107).

The function of traditional institutions

The traditional institutions determine the amount of free consumption to which households have access. The terminology most widely used in development economics to express the concept is probably that of 'entitlement'. This term, introduced by Sen refers substantially to the rights of access to goods enjoyed by an individual.[5] The first function of the traditional institutions is to provide entitlements for the poorer population, to two forms of local commons:

(i) natural local commons (agricoltural land, trees, grazing land, water etc.) generally owned by the community;

[4] "In paesant societies, leisure time included liturgical time for villagers to praise their God and common time, to assuage their mutual fears, dissipate mutual tensions and affirm their allegiance to community values. It, moreover, continued to give expression to those common values by maintaining through time a hierarchical ordering of leisure – which paralleled a similar orderingo f landholding, consumption, and power. With the displacement of paesant comunities by the new urban-industrial society, however, all this changed. Leisure time bacame subsumed within, and an adjunct to, work-time" (Blanchard, 1994, p.21).

[5] See Sen (1983). The research that led to formulation of the concept was originally concerned with famine. Sen sought to answer the question: why do famines occur in the presence of an increase in per-capita food production? His answer was that these are cases in which economic development has been successful from the point of view of aggregate production but it has failed in its distribution of entitlements reducing the food entitlements of broad segments of the population.

(ii) social local commons as in particular various forms of solidarity. This latter too can be treated as a free local resource, which in this case takes the nature of an insurance provided by kinship, clan and village relations, etc..

The second function of the traditional institutions is to provide a coordination mechanism for agents. Traditional agriculture is based, in fact, on collective action in the production and maintenance of the stock of certain crucial commons: irrigation structures, fertility management, regulation of fishing, grazing, tree cutting, use of water, waste disposal, prevention from erosion, desertification, wild fires, etc..

The fundamental effect of the decline of the traditional institutions has therefore been that of:

(i) depriving the poorer segments of the population of their entitlements to local commons, including social solidarity, thereby depriving them of every right on resources that is not purchased and therefore does not depend on income;

(ii) causing the general conditions of traditional agriculture to deteriorate owing to the decay of the coordination mechanism for crucial resources. The breakdown of traditional institutions has resulted in a "tragedy of unmanaged commons".[6]

Both effects provide incentives to increase the participation of individuals to the market sector of the economy, namely the labor and goods markets.

Institutional shocks

The model predicts that an institutional shock which causes a collapse of the endowment of commonly owned resources will increase per-capita output. In the long run the economy will resume the steady-state per-capita output determined by its structural features.

Explanations *à la* Polanyi (1968) of the role of institutional shocks in determining growth accept the neo-institutionalist emphasis on the importance of the formation of new property rights. But they give an

[6] See Bromley and Chapagain (1984), Larson and Bromley (1990), Brown (1991), Randhir and Lee (1996). As the same Hardin pointed out, the "tragedy of commons" is in reality connected to the passage from managed to unmanaged commons due to the decline of the traditional institutions. This latter is an important reason for the problems of sustainability connected with the deterioration of local commons (including solidarity). The traditional institutions in fact manage resources prudently, often unconsciously as individuals observe religious, cultural and other practices finely honed to their environment. The fact that civilizations of the past have been responsible for severe ecological breakdowns is evidence of the vulnerability of the traditional institutions to population increase, not of their lack of concern for the sustainability of resources.

explanation of its role in determining growth which differs entirely from that couched in terms of the increased efficiency, accumulation and technical progress brought about by the internalization of externalities.[7] In Polanyi's context the extension of exclusion rights may trigger growth because it restricts rights of free access to resources.[8] The two explanations are not incompatible: the explanation in terms of a decline in free consumption may point to a further reason why private property generates growth. After all, the mechanism *à la* Polanyi may be considered to be the reverse side of the neo-institutionalist mechanism: the attribution of exclusion rights to someone alters his/her decisions concerning the use of the resource, which becomes subject to his/her right but also reduces someone else's right of access to that resource. In our terms Polanyi emphasizes the general equilibrium reaction to this reduction: increased participation in the labor and product markets.

Indeterminacy and social conventions

Those with a background in economics do not seek answers to broad issues such as the causes of early modern economic growth by focusing on changes in cultural values, social conventions, mental habits and life-styles. Indeed, such approach is considered more akin to the terrain of sociology and anthropology (see Schuurman and Walsh, 1994). In contrast, the economist's approach amounts to explaining economic phenomena by tracing them back to "economic fundamentals", i.e., to technologies, preferences and endowments. This paper allows to reconcile these different approaches by showing that – in general – economic fundamentals do not determine an unique evolutionary trajectory but are consistent with more than one long-term trend. As a matter of fact, in these situations of global indeterminacy there is a natural call for explanation combining the role of economic fundamentals in determining the range of possible growth paths with the importance of cultural values and social conventions in selecting the trajectory along which the economy will move.[9] This is because individual behavior is contextual or social behavior (see Bryant, 1993), conditional on time and place and on the physical as well as the social environment (see van Ees and Garretsen, 1996). Therefore, in our model

[7] In North's growth theory, around 10,000 years of human economic progress have been driven by the formation of rights (first communal and then private) on resources (see North and Thomas, 1973; North, 1981).
[8] Transition since the end of state socialism in East Europe can be interpreted as another social experiment in growth set in train by the collapse of institutions allowing the free consumption of (low quality) goods and services.
[9] We share the idea that the many rules, conventions and institutions that shape social behavior are rarely the explicit outcome of rational design (see Sugden, 1989).

the realization of a long-term equilibrium characterized by higher environmental quality and lower level of production and consumption of private goods may depend on the cultural hegemony of a "conservationist" attitude toward environmental resources and social assets.

Policy responses

In the endogenous growth literature, markets are incomplete (given that there are positive externalities) and growth is sub-optimal (if markets for positive externalities existed, steady state growth rates would be higher). This implies that the completeness of markets generates growth. In our model, by contrast, the completeness of markets lowers the level of economic activity, and this increases households' utility. The fact that the creation of a market for the commonly owned resource would reduce the level of economic activity is not inconsistent with our claim that the growth process involves the progressive substitution of goods purchased on the marketplace for commonly owned resources. Our viewpoint, indeed, is that the combination of excessive depletion of commonly owned assets and inefficiently high level of privately owned consumer goods which characterizes the market economy calls for some collective action (creation of markets for environmental resources, creation of authorities managing these resources…). This call for collective action is consistent with the hypothesis that "even for those dimensions of environmental quality where growth seems to have been associated with improving conditions, there is no reason to believe that the process is an automatic one", since "the stongest link between income and pollution in fact is via an induced policy response" (Grossman and Krueger, 1995: pp.371-372). In its turn, this policy response is driven by citizen demand.[10]

Furthermore, the presence of some coordination failure leading the market economy to converge on a Pareto-inferior steady state characterized by a relatively high share of total households' time devoted to market activities may justify some public intervention to coordinate individual behavior. For instance, one could argue that a legislation imposing a generalized reduction of the working hours is

[10] In the debate on the so-called 'environmental Kutznets curve', i.e., on the hypothesis that the relationship between per capita income and environmental degradation takes an inverted U-shaped form, also Arrow et al. (1995) claim that economic growth is no substitute for environmental policy. Moreover, they note that "reductions in one pollutant in one country may involve increases in other pollutants in the same country or transfers of pollutants to other countries" (Arrow et al., 1995: p. 92). Estimating a dynamic model, De Bruyn et al. (1998) show that economic growth has a direct positive effect on the levels of emissions, thus supporting the radical standpoint, according to which the idea that economic growth can be good for the environment is 'false and pernicious nonsense' (see Ayres, 1995). However, it should be emphasised that sustainability is not simply a function of the levels of emissions and resource depletion, since

Pareto-improving on the grounds that individuals are induced to an excessive sacrifice of leisure only because they expect that also the others will do the same, thus causing an excessive depletion of environmental and social assets.

2. THE MODEL

We consider an economy in discrete time with an infinite horizon. Identical households and firms operate in this economy.

The households

Population is constant: the large number of households is normalized to be one. Households have finite lifetimes: they have a strictly positive and constant probability σ, $0<\sigma<1$, of dying in each period. Thus, the probability of dying in a certain period is assumed to be independent of the age of the individual; and it is also assumed that the mortality rate of a large group of households does not fluctuate stochastically even though each individual's lifespan is uncertain. This implies that at the end of each period a constant number $1-\sigma$ of households dies and is replaced by an equal number of newly born individuals.

The period utility function of the representative household is the following:

$$U_t=\beta\ln(x_t)+(1-\beta)\ln(l_t),\ 0<\beta<1. \tag{1a}$$

where x_t is the amount of services generated by some consumer activity and l_t is leisure. For simplicity, the technology used by households to produce the services positively entering their utility function is assumed to be linear:

$$x_t=R_t+\delta y_t,\ \delta>0, \tag{1b}$$

where R_t is the stock of a natural resource in period t and y_t is the quantity consumed in t of the single (and non-storable) good produced in the economy. Note that R_t may be interpreted as an indicator of the quality in t of some environmental resource to which all households have access for free in every period. In other words, R_t has the nonexclusive nature typical of a resource of common property. It cannot be produced and it has a good that can be privately appropriated as its substitute in consumption. Indeed, δ measures the efficiency of y_t as a substitute for the environmental resource. It may be interpreted as a strictly

it depends on the capacity of natural systems to absorb wastes and renew resources (see Kaufmann and Cleveland, technological parameter prescribing the quantity of y_t that is necessary-given the stock R_t-to produce the amount of x_t desired by the consumers.

The total amount of time available to each household in every period is normalized to be one. Thus,

$$l_t = 1 - h_t,\ 0 \le h_t \le 1, \qquad (1c)$$

where h_t are the units of time spent working in period t by the representative household.

Since households sell their labor services to identical firms, and since firms' profits are evenly distributed among identical households, the period budget constraint of the representative consumer is the following:

$$y_t \le w_t h_t + \pi_t, \qquad (1d)$$

where the single produced good is the numeraire of the system, w_t is the wage rate per unit of time and π_t is the share of total profits distributed to each household. For simplicity, we assume that property rights on firms are evenly distributed as households' initial endowment: newly born individuals inherit their claims on firms' profits from the households that have just died. Since both households and firms are identical, we can ignore the possibility that these rights are traded among agents.

Therefore, in each period t, the representative household must choose the amount of y_t to buy and the amount of h_t to sell in order to

$$\max \sum_{i=0}^{\infty} \theta^i U_{t+i},\ \theta \equiv \gamma(1-\sigma),\ 0 < \gamma < 1,\ t = 0,1,2..., \qquad (2)$$

subject to (1).

Note that γ is a time-preference parameter and that the problem in (2) amounts to a sequence of static single-period problems, since there is no asset that the representative agent can accumulate.

The firms

There is a large number (normalized to be one) of perfectly competitive firms. The representative firm produces a non-storable good according to the technology

$$y_t = (h_t N_t)^{1/2}, \qquad (3)$$

where N_t is the number of workers employed in t.

1995).

In each period, the representative firm must choose the combination of h_t and N_t that maximizes its profits π_t, where

$$\pi_t=y_t-h_tN_tw_t. \qquad (4)$$

Note that the working time of each individual worker employed by the firm is not institutionally set: the absence of any institutional constraint limiting the firms' possibility to determine the working time of their employees is consistent with a pure *laissez-faire* regime.

<u>The natural resource</u>

Given the lack of property rights on the natural resource, firms can freely dispose of their polluting waste. Although a single firm's productive activity has a negligible impact on the environmental quality, the aggregate effect of firms' production on R_t is not negligible. Thus, we assume that the time evolution of the natural resource is governed by

$$R_t=\omega R_{t-1}+S-\varepsilon y_t,\ R_{-1} \text{ given},\ 0<\omega<1,\ S>0,\ \varepsilon>0,\ R_t\geq 0\ \forall t,\ t=0,1,2\dots . \qquad (5)$$

Equation (5) models a productive technology whose negative impact on the environment occurs while production takes place. Indeed, εy_t represents the pollution generated by the production taking place in t and affecting R_t (ε is a parameter capturing the "dirtiness" of the technology). Moreover, $S-(1-\omega)R_{t-1}$ is the nature's absorption capacity, that is the amount of pollution that can be assimilated without a change in environmental quality (see Smulders, 2000). A high level of environmental quality can be preserved only if the level of production is low, and -- in the absence of any production -- R_t converges monotonically to $S/(1-\omega)$. Finally, note that $y_t\leq 1$, since each firm produces according to (3), and the number of firms, the number of households and the household's endowment of time are normalized to be one.

3. MARKET EQUILIBRIA WITHIN A SINGLE-PERIOD TIME HORIZON

<u>Optimality conditions</u>

From (2) and the comment just after it, the representative household's problem is to maximize (1a) subject to (1d). Eliminating x_t by using (1b) and l_t by using (1c), the problem to be solved by the representative household in period t can be rewritten as

$$\max_{y_t,h_t} \beta\ln(R_t+\delta y_t)+(1-\beta)\ln(1-h_t) \qquad (6)$$

subject to (1d), from which one obtains the following optimality condition for an interior solution:

$$\frac{\delta\beta}{R_t + \delta y_t} = \frac{1-\beta}{w_t - (y_t - \pi_t)}. \tag{7a}$$

According to (7a), a household allocates its time to work up to the point at which the increment in utility due to the additional unit of consumer good that it can buy thanks to a marginal increase of the time devoted to work is equal to the increment in utility that it can obtain by devoting an additional unit of time to leisure. Note that in order to decide about y_t and h_t, households must assess the values taken by R_t, w_t and π_t in the current period.

From the representative firm's problem of profit maximization, we obtain the following optimality condition:

$$\frac{1}{2(h_t N_t)^{1/2}} = w_t , \tag{8}$$

which states that the marginal productivity of labor must be equalized to the cost of one unit of time.

Market equilibrium conditions

Equilibrium in the product market and in the labor market implies, respectively,

$$y_t^d = y_t^s , \tag{9a}$$

and

$$h_t^d = h_t^s , \tag{9b}$$

$$N_t^d = N_t^s = 1, \tag{9c}$$

where (9c) is motivated by the fact that all the households (whose number is normalized to be one) actively participate in the labor market.

Using (1d) to rewrite the denominator of (7a)'s right-hand side as $w_t(1-h_t)$, then using (8), (3) and (5) to eliminate w_t , h_t and R_t from (7a), and finally applying N_t=1 in accordance with (9c), one can rewrite (7a) as

$$v(h_t, R_{t-1}) = \frac{\delta\beta}{2\left[h_t^{1/2}(\omega R_{t-1} + S) + (\delta - \varepsilon)h_t\right]} - \frac{(1-\beta)}{(1-h_t)} = 0. \tag{7b}$$

One can use (3) so as to rearrange (7b) obtaining the equilibrium condition

$$f(\mathrm{y}_t, \mathrm{R}_{t\text{-}1}) = \frac{\beta}{\mathrm{y}_t(2-\beta)} - \frac{(1-\beta)2(\omega \mathrm{R}_{t\text{-}1} + \mathrm{S} - \varepsilon \mathrm{y}_t)}{\delta(2-\beta)} - \mathrm{y}_t = 0. \tag{10a}$$

Given the past history of the economy, condition (10a) determines the equilibrium level of economic activity. Multiple equilibria are possible due to the presence of static externalities: given that $f(y_t,R_{t-1})=0$ is a quadratic equation, we may have zero, one or (at most) two equilibrium levels of y_t that are consistent with the non-depletion of the natural resource (i.e., with $R_t>0$).

Proposition 1 A unique equilibrium $y_t^{\bullet}>0$ exists for any combination of parameter values and R_{t-1} which satisfies these conditions: i) $\varepsilon-\delta<\omega R_{t-1}+S$ (entailing $f(y_t,R_{t-1})<0$ at $y_t=1$), or alternatively $\varepsilon-\delta=\omega R_{t-1}+S$ and $\varepsilon(1-\beta)\leq\delta$ (entailing $f(y_t,R_{t-1})=0$ at $y_t=1$ and $y_t^{\bullet}=1$), and ii) $\beta\varepsilon^2<(2-\beta)(\omega R_{t-1}+S)^2$ (entailing $R_t=\omega R_{t-1}+S-\varepsilon y_t^{\bullet}>0$), where

$$\mathrm{y}_t^{\bullet} = \begin{cases} \dfrac{(1-\beta)(\omega \mathrm{R}_{t\text{-}1}+\mathrm{S})}{[2\varepsilon(1-\beta)-\delta(2-\beta)]} - \left\{\left[\dfrac{(1-\beta)(\omega \mathrm{R}_{t\text{-}1}+\mathrm{S})}{[2\varepsilon(1-\beta)-\delta(2-\beta)]}\right]^2 - \dfrac{\beta\delta}{[2\varepsilon(1-\beta)-\delta(2-\beta)]}\right\}^{1/2} & \text{if } \varepsilon > \dfrac{\delta(2-\beta)}{2(1-\beta)} \\ \dfrac{\delta\beta}{(1-\beta)2(\omega \mathrm{R}_{t\text{-}1}+\mathrm{S})} & \text{if } \varepsilon = \dfrac{\delta(2-\beta)}{2(1-\beta)} \\ \dfrac{(1-\beta)(\omega \mathrm{R}_{t\text{-}1}+\mathrm{S})}{[2\varepsilon(1-\beta)-\delta(2-\beta)]} + \left\{\left[\dfrac{(1-\beta)(\omega \mathrm{R}_{t\text{-}1}+\mathrm{S})}{[2\varepsilon(1-\beta)-\delta(2-\beta)]}\right]^2 - \dfrac{\beta\delta}{[2\varepsilon(1-\beta)-\delta(2-\beta)]}\right\}^{1/2} & \text{otherwise.} \end{cases} \tag{11}$$

Proof:

a) By inspecting (10a), it is easy to check that f is continuous in y_t for $0<y_t\leq1$.

b) By inspecting (10a), it is also easy to check that $f(y_t,R_{t-1})>0$ as $y_t\to0$.

c) $f_{\mathrm{y}_t\mathrm{y}_t} = \dfrac{2}{\mathrm{y}_t^3(2-\beta)} > 0$.

These three facts together guarantee that in the interval (0,1] there is a unique real root solving (10a) if and only if condition i) holds (see Fig.1). Moreover, by inspecting (11), it is easy to check that this root is consistent with $R_t>0$ if and only if condition ii) holds.

Numerical examples show that there are admissible combinations of parameter values satisfying i) and ii).[11]

Proposition 2 Two equilibria y_t^* and y_t^{**}, $y_t^* > y_t^{**}>0$, exist for any combination of parameter values and R_{t-1} which satisfies these inequalities: iii) $\varepsilon-\delta\geq\omega R_{t-1}+S$ (entailing $f(y_t,R_{t-1})\geq 0$ at $y_t=1$), iv) $[(1-\beta)(\omega R_{t-1}+S)]^2>\beta\delta[2\varepsilon(1-\beta)-\delta(2-\beta)]$ and $\varepsilon(1-\beta)>\delta$ (entailing $f_{y_t}=0$ for some $y_t<1$ such that $f(y_t,R_{t-1})<0$), and v) $\beta\varepsilon^2>(2-\beta)(\omega R_{t-1}+S)^2$ (entailing $R_t=\omega R_{t-1}+S-\varepsilon y_t^*\geq>0$), where

$$y_t^* = g(R_{t-1}) = \frac{(1-\beta)(\omega R_{t-1}+S)}{[2\varepsilon(1-\beta)-\delta(2-\beta)]} + \left\{\left[\frac{(1-\beta)(\omega R_{t-1}+S)}{[2\varepsilon(1-\beta)-\delta(2-\beta)]}\right]^2 - \frac{\beta\delta}{[2\varepsilon(1-\beta)-\delta(2-\beta)]}\right\}^{1/2}, \quad (12a)$$

$$y_t^{**} = k(R_{t-1}) = \frac{(1-\beta)(\omega R_{t-1}+S)}{[2\varepsilon(1-\beta)-\delta(2-\beta)]} - \left\{\left[\frac{(1-\beta)(\omega R_{t-1}+S)}{[2\varepsilon(1-\beta)-\delta(2-\beta)]}\right]^2 - \frac{\beta\delta}{[2\varepsilon(1-\beta)-\delta(2-\beta)]}\right\}^{1/2}. \quad (12b)$$

Proof:

Again, facts a), b) and c) together guarantee that in the interval (0,1] there are exactly two real roots solving (10a) if and only if both condition iii) and condition iv) hold (see Fig. 2). Moreover, by inspecting (12), it is easy to check that both these roots are consistent with the condition $R_t>0$ if and only if condition v) holds.

Numerical examples show that there are admissible combinations of parameter values satisfying iii), iv) and v).[12]

In the presence of two equilibria, market fundamentals do not permit to determine which of the two possible equilibria is realized. Individual actions are based on expectations concerning others' actions, and it is reasonable to argue that social conventions and cultural values play an important role in coordinating individual behavior. Hence, one may argue that the economy tends to settle in y_t^* if the prevailing mentality is consistent with a society based on a mix of hard work and high consumption expenditures, or in y_t^{**} if the dominant culture emphasizes a "conservationist" approach toward natural resources.

[11] Let β=.5, ε=.8, δ=.4, ω=.25, S=.45, R_{t-1}=.2. One can check that these parameters values satisfy i), and ii). Given these values, one has $y_t^{\bullet}$=.5.

[12] Let β=.5, ε=1, δ=.1, ω=.25, S=.4069349, R_{t-1}=.2. One can check that these parameters values satisfy iii), iv) and v). Given these values, one has y_t^*=.3846384 and y_t^{**}=.152932.

INSERT FIGURE 1 AND FIGURE 2

4. MARKET EQUILIBRIUM PATHS

Steady states

By considering (5), one can rewrite the condition (10a) as

$$f(y_t, R_t) = \frac{\beta}{y_t(2-\beta)} - \frac{(1-\beta)2R_t}{\delta(2-\beta)} - y_t = 0. \tag{10b}$$

Condition (10b) allows us to express R_t as a function of y_t:

$$R_t = R(y_t) = \frac{\beta\delta}{2y_t(1-\beta)} - \frac{\delta(2-\beta)y_t}{(1-\beta)2}, \tag{13}$$

where $R_t>0$ implies

$$y_t < \bar{y} = \left[\frac{\beta}{(2-\beta)}\right]^{1/2}. \tag{14}$$

By substituting $R(y_{t-1})$ for R_{t-1} in (10a), we obtain the difference equation in y_t governing the equilibrium path of the economy:

$$f(y_t, R(y_{t-1})) = \frac{\beta}{y_t(2-\beta)} - \frac{(1-\beta)2(\omega R(y_{t-1}) + S - \varepsilon y_t)}{\delta(2-\beta)} - y_t = 0, \quad t=0,1,2\ldots, \tag{10c}$$

where – consistently with (5) and (13) -- the initial condition is

$$y_{-1} = y(R_{-1}) = \frac{-R_{-1}(1-\beta)}{\delta(2-\beta)} + \left\{\left[\frac{R_{-1}(1-\beta)}{\delta(2-\beta)}\right]^2 + \frac{\beta}{(2-\beta)}\right\}^{1/2}, \ R_{-1} \text{ given.} \tag{15}$$

By setting $y_t=y_{t-1}=y$ in (10c), one can solve for the steady-state values of y_t. Again, we may have zero, one or (at most) two steady-state values of y_t that are consistent with the non-depletion of the natural resource. In particular:

Proposition 3 A unique steady state $y\bullet>0$ exists for any combination of parameter values which satisfies these conditions: vi) $\varepsilon-\delta(1-\omega)<S$ (entailing $f(y,R(y))<0$ at $y=1$), or alternatively $\varepsilon-\delta(1-\omega)=S$ and $\varepsilon(1-\beta)\leq\delta(1-\omega)$ (entailing $f(y,R(y))=0$ at $y=1$ and $y\bullet=1$), and vii) $\beta\varepsilon^2<(2-\beta)S^2$ (entailing $R(y\bullet)=\omega R(y\bullet)+S-\varepsilon y\bullet>0$), where

$$
y\bullet=\begin{cases}\dfrac{(1-\beta)S}{[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]}-\left\{\dfrac{[(1-\beta)S]^2-\beta\delta(1-\omega)[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]}{[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]^2}\right\}^{1/2} & \text{if } \varepsilon>\dfrac{\delta(1-\omega)(2-\beta)}{2(1-\beta)}\\[2ex] \dfrac{\delta\beta(1-\omega)}{2S(1-\beta)} \quad \text{if } \varepsilon=\dfrac{\delta(1-\omega)(2-\beta)}{2(1-\beta)} & \\[2ex] \dfrac{(1-\beta)S}{[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]}+\left\{\dfrac{[(1-\beta)S]^2-\beta\delta(1-\omega)[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]}{[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]^2}\right\}^{1/2} & \text{otherwise.}\end{cases} \tag{16}
$$

Proof:

See the proof of Proposition 1.

Numerical examples show that there are admissible combinations of parameter values satisfying vi) and vii).[13]

Proposition 4 Two steady states y* and y** (such that y*>y**>0 and R*=*R*(y*)<R**=*R*(y**)) exist for any combination of parameter values which satisfies these inequalities: viii) ε-δ(1-ω)≥S (entailing *f*(y,*R*(y))≥0 at y=1), ix) $[(1-\beta)S]^2>\beta\delta[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)](1-\omega)$ and ε(1-β)>δ(1-ω) (entailing $f_y=0$ for some y<1 such that *f*(y,*R*(y))<0), and x) $\beta\varepsilon^2>(2-\beta)S^2$ (entailing *R*(y*)=ω*R*(y*)+S-εy*>0), where

$$
y^*=\frac{(1-\beta)S}{[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]}+\left\{\frac{[(1-\beta)S]^2-\beta\delta(1-\omega)[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]}{[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]^2}\right\}^{1/2}, \tag{17a}
$$

$$
y^{**}=\frac{(1-\beta)S}{[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]}-\left\{\frac{[(1-\beta)S]^2-\beta\delta(1-\omega)[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]}{[2\varepsilon(1-\beta)-\delta(1-\omega)(2-\beta)]^2}\right\}^{1/2}. \tag{17b}
$$

Proof:

See the proof of Proposition 2.

Numerical examples show that there are admissible combinations of parameter values satisfying viii), ix) and x).[14]

---

[13] Let β=.5, ε=.7, δ=.4, ω=.25, S=.5. One can check that these parameters values satisfy vi), and vii). Given these values, one has y•=.36754.

[14] Let β=.5, ε=1, δ=.1, ω=.25 and S=.4069349. One can check that these parameters values satisfy viii), ix) and x). Given these values, one has y*=.330778 and y**=.1277397.

Note that in a neighborhood of y* the economy is governed by $y_t = g(R(y_{t-1}))$, where $g(R(y_{t-1}))$ is obtained by using (13) for substituting R_{t-1} in (12a). Similarly, in a neighborhood of y** the economy is governed by $y_t = k(R(y_{t-1}))$, where $k(R(y_{t-1}))$ is obtained by using (13) for substituting R_{t-1} in (12b). Moreover, one can inspect (12) to conclude that both $g(R(y_{t-1}))$ and $k(R(y_{t-1}))$ are defined for $y_{t-1} \in [0, \tilde{y}]$,

where $\tilde{y} = \frac{(1-\beta)S - \{\beta\delta[2\varepsilon(1-\beta) - \delta(2-\beta)]\}^{1/2}}{\delta\omega(2-\beta)} + \left\{ \left[\frac{(1-\beta)S - \{\beta\delta[2\varepsilon(1-\beta) - \delta(2-\beta)]\}^{1/2}}{\delta\omega(2-\beta)} \right]^2 + \frac{\beta}{(2-\beta)} \right\}^{1/2}$ is

that value of y_{t-1} at which $g(R(y_{t-1})) = k(R(y_{t-1}))$.[15] Finally, one can check that for $y_{t-1} \in [0, \tilde{y})$ one has:

$$\frac{dg(R(y_{t-1}))}{dy_{t-1}} = \frac{(1-\beta)\omega g(R(y_{t-1}))}{[2\varepsilon(1-\beta) - \delta(2-\beta)]} \frac{dR(y_{t-1})}{dy_{t-1}} \left\{ \left[\frac{(1-\beta)(\omega R(y_{t-1}) + S)}{[2\varepsilon(1-\beta) - \delta(2-\beta)]} \right]^2 - \frac{\beta\delta}{[2\varepsilon(1-\beta) - \delta(2-\beta)]} \right\}^{-1/2} < 0 \quad (18a)$$

and

$$\frac{dk(R(y_{t-1}))}{dy_{t-1}} = \frac{-(1-\beta)\omega k(R(y_{t-1}))}{[2\varepsilon(1-\beta) - \delta(2-\beta)]} \frac{dR(y_{t-1})}{dy_{t-1}} \left\{ \left[\frac{(1-\beta)(\omega R(y_{t-1}) + S)}{[2\varepsilon(1-\beta) - \delta(2-\beta)]} \right]^2 - \frac{\beta\delta}{[2\varepsilon(1-\beta) - \delta(2-\beta)]} \right\}^{-1/2} > 0, \quad (18b)$$

where $\frac{dR(y_{t-1})}{dy_{t-1}} = \frac{-\delta\left(\beta y_{t-1}^{-2} + 2 - \beta\right)}{2(1-\beta)} < 0$ (see Fig. 3).

INSERT FIGURE 3

Global indeterminacy

In the presence of two steady states, it may be the case that the economic fundamentals (parameter values and initial condition) are not enough to determine the long-run equilibrium to which the economy converges: given the initial condition R_{-1}, the economy may end up in y* or alternatively in y** depending on the dominant social conventions and cultural values (global indeterminacy).

Proposition 5 For any combination of parameter values which satisfies the inequalities viii), ix), x) (entailing the existence of y* and y**) and xi) $-1 < \left.\frac{dg(R(y_{t-1}))}{dy_{t-1}}\right|_{y_{t-1}=y^*} < 0$ (entailing the local stability of y*), there exists some initial condition R_{-1} consistent with the convergence of the economy to y* or to y**.

[15] The condition $R_t>0$ is satisfied at $y_{t-1}=\tilde{y}$ if the parameter values are such that $\tilde{y} < \bar{y}$. One can check that parameter values entailing $\tilde{y} < \bar{y}$ are consistent with the existence of two steady states. For example, with the parameter values given in the preceding note, one has $\tilde{y}$ =.5101 and $\bar{y}$ =.57735.

Proof:

a) Because of xi), any sequence $\{y_{t-1}\}_{t=0}^{\infty}$ generated by $y_t=g(R(y_{t-1}))$ whose first element y_{-1} is in a neighborhood of y* converges to y*.

b) Because of xi), of (18a) and of the fact that $\frac{dg(R(y_{t-1}))}{dy_{t-1}} \to -\infty$ as $y_{t-1} \to \tilde{y}$, one has: $y^* < \tilde{y}$ and $g(R(y_{t-1}))<y^*$ at $y_{t-1}=\tilde{y}$. Together with (18b), with y*>y** and with the fact that $g(R(y_{t-1}))=k(R(y_{t-1}))$ at $y_{t-1}=\tilde{y}$, this entails: $y_t=k(R(y_{t-1}))>y_{t-1}$ at any y_{t-1} such that $0 \le y_{t-1}<y^{**}$, and $y_t=k(R(y_{t-1}))<y_{t-1}$ at any y_{t-1} such that $y^{**}<y_{t-1} \le \tilde{y}$ (see Fig. 3). Thus, any sequence $\{y_{t-1}\}_{t=0}^{\infty}$ generated by $y_t=k(R(y_{t-1}))$ whose first element is $y_{-1} \in [0, \tilde{y}]$ converges (monotonically) to y**.

Given a) and b), any initial condition R_{-1} such that $y_{-1}=y(R_{-1})$ is in a neighborhood of y* (entailing $y_{-1}=y(R_{-1}) \in [0, \tilde{y}]$) is consistent with the economy converging to y* or to y**.

Numerical examples show that there are admissible combinations of parameter values satisfying viii), ix), and x) and xi).[16]

If the inequalities viii), ix), x) and xi) are satisfied, the economy may be entrapped around the steady state (y*, R*=R(y*)), and it may end up oscillating around its long-term equilibrium characterized by a higher level of economic activity and worse environmental quality. Indeed, if the social conventions and values underlying the equilibrium outcome $y_t=g(R(y_{t-1}))$ tend to dominate for a prolonged period of time, a shock that perturbs the long-term equilibrium (y*, R*=R(y*)) causing a marginal improvement in the quality of the environment cannot give rise to a cumulative process of environmental improvement and reduction of economic activity. It is only a change in the dominant social conventions that can give rise to such a process by allowing the economy to jump on the path $y_t=k(R(y_{t-1}))$ so as to converge toward (y**, R**=R(y**)).

---

[16] Given the parameter values of footnote 14 (which satisfy viii), ix) and x)), one has $\left.\frac{dg(R(y_{t-1}))}{dy_{t-1}}\right|_{y_{t-1}=y^*} = -.386$.

Taking these parameter values and $R_{-1}=.2$, one has: $y_0=.3846384=g(R(y_{-1}))$, $y_1=.310661=g(R(y_0))$, $y_2=.3387087=g(R(y_1))$, $y_3=.3277379=g(R(y_2))$, $y_4=.3319559=g(R(y_3))$, $y_5=.3303245=g(R(y_4))$, $y_6=.330954=g(R(y_5))$ and $g(R(y_t)) \to y^*=.3307786$ as $t \to \infty$; $y_0=.152932=k(R(y_{-1}))$, $y_1=.1361682=k(R(y_0))$, $y_2=.1307113=k(R(y_1))$, $y_3=.1288067=k(R(y_2))$, $y_4=.1281253=k(R(y_3))$, $y_5=.1278793=k(R(y_4))$, $y_6=.1277901=k(R(y_5))$ and $k(R(y_t)) \to y^{**}=.1277397$ as $t \to \infty$.

However, one may speculate on the frequency of these changes by remarking that powerful forces favor cultural persistency when expectations concerning other agents' behavior are systematically fulfilled (as it is the case in this economy), thus reinforcing those social conventions and cultural values on which these expectations are based.

5. WELFARE IMPLICATIONS

The Pareto-optimal path

To evaluate the welfare implications of the market dynamics analyzed above, consider the problem of a benevolent planner with an infinite horizon:

$$\underset{\{h_t\}_0^\infty}{\text{Max}} \sum_{t=0}^{\infty} \theta^t U\left(h_t, R_{t-1}\right) \tag{19}$$

subject to $0 \leq h_t \leq 1$ and to $R_t = \omega R_{t-1} + S - \varepsilon h_t^{1/2} > 0$, R_{-1} given, where the single-period utility of the representative household is given by $U(h_t, R_{t-1}) = \beta \ln\left(\omega R_{t-1} + S + (\delta - \varepsilon) h_t^{1/2}\right) + (1-\beta)(1-h_t)$.

One can solve this problem by maximizing the Hamiltonian

$$H_t = \sum_{i=0}^{\infty} \theta^i \left\{ U(h_{t+i}, R_{t+i-1}) - \lambda_{t+i}\left(R_{t+i} - \omega R_{t+i-1} - S + \varepsilon h_{t+i}^{1/2} \right) + \mu_{1t+i}(1 - h_{t+i}) + \mu_{2t+i} h_{t+i} \right\} \tag{20}$$

with respect to h_{t+i}, R_{t+i} and λ_{t+i}, where the multiplier λ_{t+i} can be interpreted as the current value along an optimal program of a marginal increment in the stock of natural resource available in t, and μ_{1t+i} and μ_{2t+i} are the multipliers associated with the constraints to which the control is subject.

A Pareto-optimal path must satisfy:

$$\frac{\partial H_t}{\partial h_t} = \frac{(\delta - \varepsilon)\beta}{2\left[h_t^{1/2}(\omega R_{t-1} + S) + (\delta - \varepsilon) h_t \right]} - \frac{(1-\beta)}{(1-h_t)} - \frac{\lambda_t \varepsilon}{2 h_t^{1/2}} - \mu_{1t} + \mu_{2t} = 0, \tag{21a}$$

$$\frac{\partial H_t}{\partial R_t} = \frac{\beta\theta\omega}{\omega R_t + S + (\delta - \varepsilon) h_{t+1}^{1/2}} + \theta\omega\lambda_{t+1} - \lambda_t = 0, \tag{21b}$$

$$\frac{\partial H_t}{\partial \lambda_t} = R_t - \omega R_{t-1} - S + \varepsilon h_t^{1/2} = 0, \tag{21c}$$

$$\lim_{i\to\infty}\theta^i R_{t+i}\lambda_{t+i}=0, \tag{21d}$$

$$R_t \geq 0, \tag{21e}$$

$$\mu_{1t}\geq 0,\ \ \mu_{1t}(1-h_t)=0, \tag{21f}$$

$$\mu_{2t}\geq 0,\ \ \mu_{2t}h_t=0. \tag{21g}$$

Considering that along an optimal path $\lambda_t>0$ [17] and $\mu_{1t}=0$, [18] one can prove the following proposition:

Proposition 6 For any given R_{t-1}, the Pareto-optimal level of output, h_t°, is always strictly lower than a market-equilibrium level of output consistent with the non-depletion of the natural resource.

Proof:

a) From inspection of (7b), one can check that $v(h_t, R_{t-1})\to\infty$ as $h_t\to 0$ and $v(h_t, R_{t-1})\to -\infty$ as $h_t\to 1$ whenever there exists a non-negative value of h_t satisfying $R_t=\omega R_{t-1}+S-\varepsilon h_t^{1/2}>0$. Together with the continuity of $v(.)$ in h_t, this implies that a market-equilibrium value of h_t consistent with $R_t>0$ is always in the open interval (0,1).

b) In contrast, one can check by inspecting (21a) that the Pareto-optimal path may be characterized by the corner solution $h_t^{\circ}=0$ (in particular, one has $h_t^{\circ}=0$ when $\varepsilon\geq\delta$).

c) If this is not the case and $h_t^{\circ}>0$, then $\mu_{2t}=0$ and – considering that along an optimal path $\mu_{1t}=0$ -- the optimality condition (21a) can be written as

$$\frac{\partial H_t}{\partial h_t}=v(h_t,R_{t-1})-\frac{\varepsilon\beta}{2\left[h_t^{1/2}(\omega R_{t-1}+S)+(\delta-\varepsilon)h_t\right]}-\frac{\lambda_t\varepsilon}{2h_t^{1/2}}=0, \tag{22}$$

---

[17] This can be seen by considering that from (21b) one has

$$\lambda_t=\sum_{i=0}^{T}\frac{\beta(\theta\omega)^{i+1}}{\omega R_{t+i}+S+(\delta-\varepsilon)h_{t+i+1}^{1/2}}+(\theta\omega)^{T+1}\lambda_{t+T+1}. \qquad \text{(i)}$$

Since $\lim_{T\to\infty}(\theta\omega)^{T+1}\lambda_{t+T+1}=0$ because of the transversality condition (21d), (i) can be written as

$$\lambda_t=\sum_{i=0}^{\infty}\frac{\beta(\theta\omega)^{i+1}}{\omega R_{t+i}+S+(\delta-\varepsilon)h_{t+i+1}^{1/2}}. \qquad \text{(ii)}$$

Given (21c) and the condition (21e), (ii) must be such that $\lambda_t>0\ \forall t$.

[18] This can be seen by considering that along an optimal path $h_t\neq 1$ (and therefore from (21f) that $\mu_{1t}=0$), because if h_t did approach one, utility would go in t to $-\infty$.

where $v(\mathrm{h}_t, \mathrm{R}_{t-1})$ is given by (7b) (one can check that ε<δ is a necessary condition for having a value of $\mathrm{h}_t \in (0,1)$ which satisfies both $\mathrm{R}_t \geq 0$ and (22)). Since $\frac{\partial v(\mathrm{h}_t, \mathrm{R}_{t-1})}{\partial \mathrm{h}_t} < 0$ for ε<δ, one can compare (7b) with (22) so as to conclude that the value of h_t satisfying (22) is strictly lower than the value of h_t satisfying (7b).

Given a), b) and c), both if $\overset{\circ}{\mathrm{h}}_t = 0$ and if $\overset{\circ}{\mathrm{h}}_t > 0$, the Pareto-optimal level of output is strictly lower than the market-equilibrium level of output consistent with $\mathrm{R}_t > 0$.

According to Proposition 6, the attitude toward the exploitation of the natural resource is more "conservationist" under a benevolent planner than under a *laissez-faire* market regime. This comes as no surprise, since each individual agent has no incentive to take into account the externality that s/he causes because of his/her productive activity.

Steady-state welfare

The steady-state utility function of the representative household is the following:

$$U(\mathrm{h}, r(\mathrm{h})) = \beta \ln\left(r(\mathrm{h}) + \delta \mathrm{h}^{1/2} \right) + (1-\beta)(1-\mathrm{h}), \tag{23}$$

where $r(\mathrm{h})$ -- which is obtained by setting $\mathrm{R}=\mathrm{R}_t=\mathrm{R}_{t-1}$ and $\mathrm{y}=\mathrm{y}_t$ in (5), and by considering (3) and the fact that $\mathrm{N}_t = 1\ \forall t$ -- gives the steady-state level of R_t as a function of the steady-state level of h_t:

$$\mathrm{R} = r(\mathrm{h}) = \frac{\mathrm{S} - \varepsilon \mathrm{h}^{1/2}}{(1-\omega)}\,. \tag{24}$$

If the market economy exhibits two steady states, the representative household is better off at the steady state characterized by the lower level of economic activity than at the steady state characterized by the higher level of economic activity:

Proposition 7 If under a pure market regime there exist two steady states $\left(\mathrm{y}^* = (\mathrm{h}^*)^{1/2}, \mathrm{R}^* = R(\mathrm{y}^*) \right)$ and $\left(\mathrm{y}^{**} = (\mathrm{h}^{**})^{1/2}, \mathrm{R}^{**} = R(\mathrm{y}^{**}) \right)$, where h*>h**, then U(h**, r(h**))>U(h*, r(h*)).

Proof:

a) If the inequality viii) holds, which is necessary for having two steady state y* and y**, one has:

$$\frac{dU\left(\mathrm{h}, r(\mathrm{h})\right)}{d\mathrm{h}} = -\frac{\beta[\varepsilon - (1-\omega)\delta]}{2(1-\omega)\left(\mathrm{h}^{1/2} r(\mathrm{h}) + \delta \mathrm{h}\right)} - \frac{(1-\beta)}{(1-\mathrm{h})} < 0, \quad 0 \le \mathrm{h} \le \mathrm{h}^{**}. \tag{25}$$

From a) and the fact that h*>h**, it follows that *U*(h**, *r*(h**))>*U*(h*, *r*(h*)).

In other words, if more than one long-run equilibrium is possible in a market economy, the long-term welfare of the households is worse off when the market participants systematically tend to select the equilibrium associated with the higher level of economic activity.

6. CONCLUSION

In this paper we have shown that the depletion of a commonly owned resource may generate growth by inducing individuals to consume more market goods. In its turn, the increased consumption and production enlarge the marketplace and cause a further degradation of the common. As a result, a market equilibrium is characterized by an inefficiently high level of production and consumption and by inefficiently low levels of leisure and quality of the resource. In other words, we have a market failure.

Given the presence of negative externalities, multiple long-run equilibria may exist. This implies that in addition to the market failure we may have also a coordination failure leading the economy to be locked in a long-run equilibrium that is Pareto-dominated by some other possible steady state.

Finally, the paper discusses the possible interpretations of the model emphasizing that the common may be interpreted both as sociological and as an environmental asset.

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Fig. 1

UNIQUE EQUILIBRIUM LEVEL OF ECONOMIC ACTIVITY

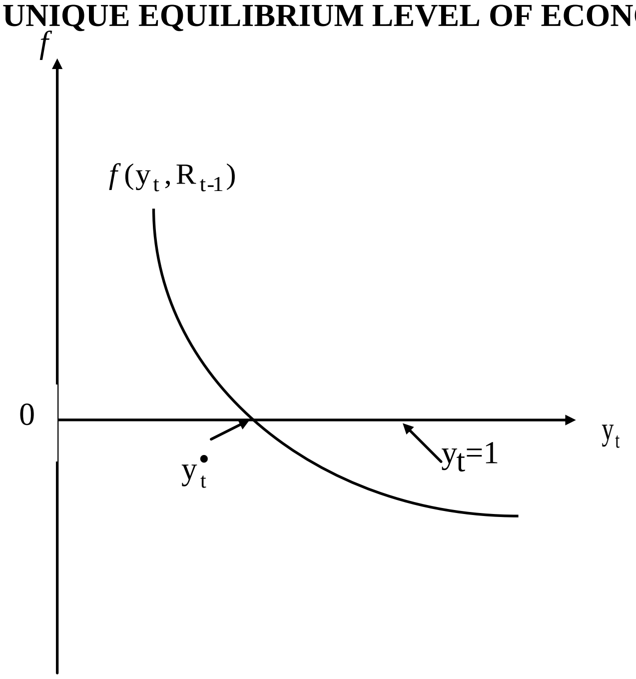

Fig. 2

TWO EQUILIBRIUM LEVELS OF ECONOMIC ACTIVITY

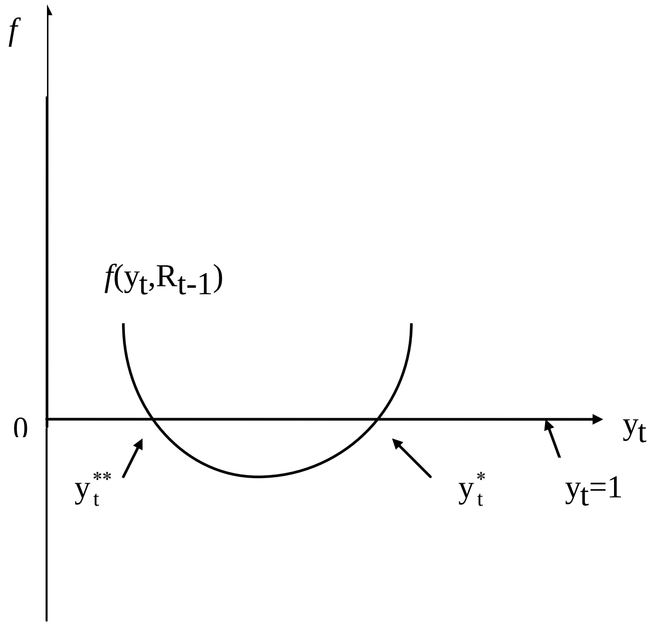

Fig. 3

PHASE LINES IN THE PRESENCE OF MULTIPLE STEADY