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**TOURISM SPECIALIZATION AND ENVIRONMENTAL  
SUSTAINABILITY IN A DYNAMIC ECONOMY**

Fabio Cerina

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# Tourism specialization and environmental sustainability in a dynamic economy\*

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## Abstract

This study focuses on the dynamic behaviour of a small open economy specialized in tourism based on natural resources. We analyse the steady-state properties in two setups, with or without public abatement expenditures and a unique locally saddle-point equilibrium is found for both cases. The analysis of the transitional dynamics allows for an alternative and "out-of-equilibrium" explanation for the observed positive growth performance of small open tourists economies and for the worldwide increase in tourist inflows. Finally, for both setups, we analyse the issue of market failures taking into account two different kinds of externality and finding the respective optimal tax rate able to induce private agents to replicate the social optimum. The corrective policy, insofar it leads to an increase in tourists' willingness to pay, works as an "implicit" tourist tax paid by tourists. who are, on the other hand, compensated with a better quality of the service purchased.

JEL CODES: H23, L83, O41, Q26, Q56.

KEYWORDS: Tourism Specialization, Sustainability, Growth, Environmental quality, Transitional dynamics, Corrective tax, Pollution Abatement.

## 1 Introduction

Recent empirical studies, such as Brau et al. (2005), have documented that, in recent years, small "tourism-economies" have grown significantly faster than non-tourism ones and their income level is above the average for small economies. Moreover, during the last 20 years, the growth performance of tourism economies has been better than the average of the OECD countries. A bunch of papers (Hazari and Sgrò, 1995, Lanza and Pigliaru, 1994 and 2000, Smeral, 2003, and

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Nowak and Sahli, 2005, among them) have tried to provide an explanation for such stylized facts. A common result of these works is that the positive growth performance can be considered a long-run equilibrium phenomenon once we allow tourism countries to "import" growth from abroad by means of continual gains in the terms of trade. Notably, all these papers don't consider the role of the environmental amenities and natural resources in the process of tourism development where the positive growth performance has interested especially countries whose tourism sector is based on natural and environmental resources. On the other hand, many authors (Tisdell, 2001 and Davies and Cahill, 2000, among them) pointed out that environmental resources interact with the process of tourism development in at least two different ways: they positively affect tourists' preferences towards the destination but, at the same time, they are negatively affected by tourists' inflows.

Once environmental resources are taken into account, some interesting questions arise: can growth be sustained in the long-run for a small open economy specialized in tourism based on environmental resources? What are the dynamic interactions between tourism development, residents' welfare and environmental resources? Does the market guarantee an optimal use of the environmental resources or are there cases of market failure that might compromise to some extent the growth performance or the levels of welfare attainable by these countries? What is the best way to respond to such market failures?

The main aim of this paper is to build a simple analytical framework where such issues can be analysed in a proper way. We develop a dynamic general equilibrium model where the main task of a small open economy specialized in tourism based on environmental resources is to choose the number of tourists to be hosted, the level of consumption and the fraction of income to be devoted to abatement efforts in order to maximize the long-run welfare of its residents, which is assumed to depend on consumption level and environmental quality. This choice has to take into account several dynamic trade-offs. First, the number of tourists have an ambiguous effect on welfare: on one hand, visitors increase tourism revenues and consumption possibilities; on the other, since tourists are assumed to negatively affect the environmental stock of resources, they also have a negative impact on welfare both directly (the environmental resources enters the residents utility function) and indirectly (tourists' are assumed to give a positive value to the environmental quality and to be crowding averse). Second, public abatement expenditures, in reducing residents' consumption possibilities, have a direct negative effect on welfare but, in reducing the marginal impact of tourists on the environment, they also have a positive effect on welfare by allowing for a higher (and in some cases increasing) number of tourists in equilibrium and hence higher tourism revenues.

We analyse the dynamic properties of the model in two different setups, with and without abatement expenditures. In both setups, the unique steady-state is found to be a saddle point and the characteristics of the transitional dynamics allows us to interpret as temporary and transitional some stylized facts such as the positive growth performance of small open tourism economies and the worldwide increasing number of tourists inflows (WTO, 2006). Interest-

ingly enough, when local authorities are able to reduce pollution flow by means of the standard abatement technology considered here (see, among the others, Smulders and Gradus, 1996 and Stokey 1998), the steady state level of environmental quality is *lower* with respect to the no-abatement case. Moreover, in the case with abatement only, when terms of trade are assumed to grow for some exogenous reasons, environmental sustainability is showed to be compatible with an increasing number of visitors in the steady state. By contrast, in the no-abatement case, a necessary condition for environmental sustainability is that the number of tourists remains constant in the steady state and exogenous growth in the terms of trade only affects steady state consumption which grows at the same rate.

Prompted by the recent important political debate in Sardinia, where the local government, motivated by the need to reduce the environmental impact of tourists, has implemented a discussed system of taxes towards non-resident second houses and use of some luxury goods, we also face some policy issues. In doing that, we take into account two different kinds of externalities which might arise in the process of tourism development: 1) a typical "tragedy of the commons" situation, suggested by the non-excludable nature of the environmental good; 2) an "informational" market failure according to which agents are not aware of tourists' preferences and therefore they do not take into account their own role in affecting tourists' willingness to pay (WTP) with their actions. We implement the proper corrective policy in both setups with and without abatement and for both kinds of externality. Notably, in the "tragedy of the commons" case, the presence of public abatement expenditures allows to reduce the total fraction of income taxed while the opposite happens in the case of the "informational" externality.

Two are the main strands of literature which the paper primarily refers to. The first one, which explicitly deals with tourism economics issues from a dynamic point of view, includes the already cited group of works Lanza and Pigliaru (1994 and 2000), Hazari and Sgro' (1995), Smeral (2003), Nowak and Sahli (2005). The present paper investigates the environmental consequences of their main results and offers an alternative (and out-of-equilibrium) explanation for such a positive performance. Among this strand we also remind Lozano et al. (2005), Gomez Gomez et al. (2004), Rey-Maqueira et al. (2004), Giannoni and Maupertuis (2005) and Candela and Cellini (2006). Explicitly dealing with environmental issues, the aims of this group of works are similar to ours though crucial differences in the modeling strategies and in the level of investigation exists<sup>1</sup>. Moreover, none of these paper allows for an explicit investigation of the

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<sup>1</sup>In particular, Giannoni and Maupertuis (2005) and Candela and Cellini (2006) adopt the point of view of a representative tourism firm aiming to maximize its lifetime profit, while this paper focuses on residents' welfare. Lozano et al. (2005) builds a dynamic general equilibrium model where also investment in accommodation capacity is taken into account, but this model only provide social optimum solution. Decentralized and optimal solutions, without explicit policy analysis, are investigated in Rey-Maqueira et al. (2004) but in a quite different framework where the conflict between agricultural and tourism sector for the use of land plays a crucial role. Gomez Gomez et al. (2004) conduct an interesting analysis of the effects of night stay taxes but, again, no decentralized solutions are taken into account.

transitional dynamics so that numeric simulations are necessary.

The other important branch of literature which this paper refers to is the massive "environmental and growth" literature (Gradus and Smulders, 1993, Smulders and Gradus 1996, Stokey 1998, Tahvonen and Kuuluvainen 1991, etc., see Beltratti 1996 and Smulders 2000 for a comprehensive survey of the literature). What distinguishes this paper from this group of works is that, as suggested by Papatheodoru (2003), the peculiarities of the tourism sector are explicitly taken into account. In particular, our framework focuses on the interplay between the number of tourists and environmental sustainability and highlights a distinctive feature of the tourism industry where the excessive demand for tourism services provided by a given destination may lead to an impoverishment of the quality of the same and, ultimately, to a worsening of the economic performance.

The rest of the paper is organized as follows: section 2 presents the general analytical framework, section 3 studies the social optimum and the decentralized solution in the model without abatement while section 4 do the same thing for the model with abatement. Section 5 concludes.

## 2 The general analytical framework

### 2.1 Tourist's preferences and the international tourism market

According to the existing literature (Brau and Cao, 2005, Crouch and Louvière, 2001), a foreign visitor might obtain satisfaction from several sources such as: 1) the quality and the quantity of services supplied by private tourists operators (accommodation, restaurants, leisure facilities), 2) the quality and the quantity of public goods provided by local authorities (public transport, informations, safety) 3) the quality and the quantity of the environmental (amenities, landscapes, beaches, mountains, parks, climate), cultural (traditional customs and events, typical food, historical buildings, museums) and social (people behaviour, general atmosphere, fascinating attitudes) resources; 4) the degree of availability and enjoyability of public goods and cultural and environmental amenities, which is highly correlated and negatively influenced by the aggregate number of visitors. Since this paper principally focuses on the interplay between the number of tourists and the stock of environmental, social and cultural resources, we restrict our attention on the last two factors. Accordingly, we assume that, at any time  $t$ , tourists' satisfaction are negatively influenced by the current aggregate number of tourists  $N_t$  and positively influenced by the current stock of environmental, social and cultural resources which we gather in a general index of "environmental quality" denoted by  $E_t$ <sup>2</sup>.

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<sup>2</sup>Taking into account the implications of the difference between purely physical aspects of the environment and its less tangible aspects, related to the social and cultural sphere, can raise interesting issues but the economic implications of this distinction goes beyond the purposes of this paper and we leave it to future works.

In formalizing tourists' preferences we follow the approach used by Gomez et al. (2004) which relies on the hedonic price theory (Rosen, 1974). The willingness to pay for tourism services is then given by

$$p_t = \gamma_t p(E_t, N_t) \quad (1)$$

Where  $\frac{\partial p}{\partial E} > 0$ ,  $\frac{\partial p}{\partial N} < 0$  and  $\gamma_t = \gamma_0 e^{gt}$  is a parameter whose constant growth rate  $g \geq 0$  reflects upward pressure on relative price of tourism for any perceived quality of tourism services depending on the interplay between growth in foreign income and the luxury nature of the tourism good (Crouch, 1995 and Smeral, 2003) or its small elasticity of substitution with other kinds of goods (Lanza and Pigliaru 1994, 2000). Our economy supplies tourism services in an international tourism market where a large number of small tourism economies participate. It is important to highlight that although international competition fixes the price for a given quality of the services, a country could charge a higher price provided that its services are considered of a higher quality (i.e. characterized by a higher stock of environmental, cultural and social resources) than other countries'. In other words, the international markets consists in a continuum of tourism markets differentiated by their quality and the (equilibrium) price paid for the tourism services. In each of them the suppliers are price-takers but they can move along the quality ladder due to changes in their environmental quality.

## 2.2 Tourism revenues and residents' behaviour

We assume that each tourist, at any time  $t$ , buys one unit of tourism services so that output at time  $t$  is measured in terms of tourist entries  $N_t$ . The supply side of the economy is made up of a large number of identical "households-firms" which we normalize to 1. We assume that the international demand for tourism is infinite for the price level which corresponds to tourists' WTP and is nil for any other price level<sup>3</sup>. So the market clears all the time and the quantity of  $N_t$  exchanged is totally determined by the supply side. For the sake of simplicity, we assume that the country provides tourism services without any labour or capital costs. In other words, we are assuming that tourists are satisfied by simply enjoying the environmental, social and cultural resources of which the country is naturally endowed. As we'll see in the next section, the only cost associated to tourists, the one which prevents the number of tourists to be infinite, is an environmental one.

Given the absence of labour and capital costs, aggregate tourism revenues correspond to aggregate profits obtained by the households-firms and is represented by the value of the economy's output

$$TR = N_t \gamma_t p(E_t, N_t) \quad (2)$$

Conceptually, this is not different from a "production function" of tourism services where  $N_t$  and  $E_t$  enter as input factors.

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<sup>3</sup>This assumption might look quite restrictive but it helps capturing the volatility of some kinds of tourism demand.

The demand side is represented by the same continuum of infinitely-lived "households-firms". Their aggregate utility, at time  $t$ , is positively influenced by the aggregate level of consumption at time  $t$  of an homogenous good purchased from abroad at a unitary price ( $C_t$ ), and by the stock of environmental, cultural and social resources at time  $t$  ( $E_t$ ). Their lifetime utility is given by an infinite discounted sum of logarithmic instantaneous utility<sup>4</sup>

$$U_t = \int_t^\infty u(C_t, E_t) e^{-\rho t} dt = \int_t^\infty (\ln C_t + \beta \ln E_t) e^{-\rho t} dt. \quad (3)$$

Notice that the stock of environmental, social and cultural resources has not only an (indirect) economic value (by positively affecting the tourists' willingness to pay) but also a value *per se* (by entering the residents' utility function).

### 2.3 The evolution of the environmental quality

We model environmental quality as an accumulable stock of renewable resources. We follow a standard approach in the environment and growth literature which has been popularized, among the others, by Bovenberg and Smulders (1995) and Smulders and Gradus (1996). The motion equation of the stock of environmental quality is then given by

$$\dot{E}_t = f(E_t) - P_t \quad (4)$$

where  $\dot{E}_t$  is the derivative of  $E_t$  with respect to time and  $P_t$  is the flow of pollution at time  $t$ . We assume  $f_E < 0$  so that the natural absorption capacity of the environment always decreases as the current stock of environment grows. Apart from some works (like Brock and Taylor, 2003, Ramirez et al. 2006, Van Marrewijk et al. 1993), the literature tends to accept the view according to which there is an upper bound to environmental quality. The motivation for this view (extensively described in Smulders 2001) is highly related to the merely "physical" interpretation that the literature generally gives to the environmental quality index and relies on the fact that the higher the quality of the environment, the more eco-services are needed to sustain this level, whereas the supply of these services is ultimately limited by solar energy because of the entropy law. It is questionable whether the assumption of an upper bounded environmental quality is appropriate even when the latter is intended in our broader sense (which fits better with tourism-related issues). Nonetheless, leaving the investigation of the issue for future research, we conform to the standard approach and we then assume that there is an upper bound  $\bar{E}$  above which environmental quality is not able to grow.

What are the determinants of the pollution flow  $P$  in an economy specialized in tourism? As already said, we abstract from physical capital in this model so that all the potential negative impacts of the tourism industry, extensively

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<sup>4</sup>Using a more general instantaneous CES function of the kind  $u(C_t, E_t) = \frac{(C_t E_t^\beta)^{1-\sigma}}{1-\sigma}$  would not add much in terms of richness of results.

discussed by Davies and Cahill (2000)<sup>5</sup>, are embodied in the variable  $N$ . In other words, pollution is considered as a by-product of the tourism industry. On the other hand, the country may undertake some actions in order to reduce this negative impact and may implement some abatement policies. Reasonably enough, the abatement effort is costly so that a country willing to undertake an abatement policy should extract resources from the output of the economy. Accordingly, the function describing the behaviour of the pollution flow may take the following form

$$P_t = P(N_t, a_t) \quad (5)$$

where  $a_t \leq y_t$  is an absolute measure of the abatement effort and represents the part of the national income devoted to abate the flow of pollution brought by tourists. Formalizing the previous intuition, we assume that  $P_N \geq 0$  and  $P_a \leq 0$ .

### 3 A model without public abatement

In this section we analyse and discuss a particular case of the general model presented above in which abatement efforts are totally ineffective in reducing the negative impact of tourists. Then  $P_a = 0$  and the accumulation equation becomes  $\dot{E}_t = f(E_t) - P(N_t)$ . Since abatement is useless, the country need not devote any resources to it. That is,  $a_t = 0$  for any  $t$  and the whole national income is used to purchase the consumption good. In order to obtain closed-form solution we introduce explicit functional forms for the relation introduced before. In particular, we assume Cobb-Douglas form for tourists' preferences

$$\gamma_t p(E_t, N_t) = \gamma_t E_t^\phi N^{-\theta} \quad (6)$$

where  $\phi$  can be interpreted as a measure of preference for the environmental quality, while  $\theta$  is a measure of crowding aversion. We assume that both  $\phi$  and  $\theta$  belong to the interval  $[0, 1) \subset \mathbb{R}^2$  so that  $p_E \geq 0, p_{EE} \leq 0$  and  $p_N \leq 0, p_{NN} \geq 0$ .<sup>6</sup>

<sup>5</sup>Davies and Cahill give an account of the environmental impacts of tourism such as energy consumption, water consumption, wasters, impact on water and air quality, ecosystems alteration and fragmentation, impacts on wildlife and on aesthetic and cultural environment.

<sup>6</sup>Notice that (6) can be also written as

$$p_t = \gamma_t \left( \frac{E_t}{n_t} \right)^\phi n_t^{\phi-\theta}$$

so that the willingness to pay can be viewed as an increasing and concave function of "per-capita environment"  $\left( \frac{E}{n} \right)$  and an increasing or decreasing concave function of the number of tourist entries depending on whether  $\phi - \theta$  is positive or negative. Alternatively, we can interpret the inverse of per-capita environment  $\left( \frac{n}{E} \right)$  as a measure of the crowding of the destination so that we are basically assuming that tourists are *crowding-averse*. The term  $n_t^{\phi-\theta}$  can be considered as an additional preference (if  $\phi > \theta$ ) or aversion (if  $\theta > \phi$ ) over the number of tourists in the destination. In particular, we can associate  $\phi > \theta$  to a preference for mass tourism and  $\phi < \theta$  to a preference for "elite" or snobbish tourism.

The accumulation equation of the environmental quality takes the following form which can be also found in Becker (1982), Cazzavillan and Musu (2001), Gomez et al. (2004), Lozano et al. (2005)

$$\dot{E} = m(\bar{E} - E_t) - \alpha N_t^\eta \quad (7)$$

As already anticipated,  $\bar{E}$  represents the upper bound to the environmental quality and  $(\bar{E} - E_t)$ , the difference between the maximum and the current level of the environmental quality, can be interpreted as the current stock of pollution.  $m \in (0, 1)$  is the constant proportion of the stock of pollution which is assimilated at each date  $t$  by the natural factors that govern the economy. The flow of pollution is  $P(N_t) = \alpha N_t^\eta$  where  $\alpha$  is a positive scaling parameter and  $\eta$  is the positive constant elasticity of the flow of pollution with respect to  $N$ . At this stage of the model, we do not introduce any other restriction on  $\eta$ . When no resources can be devoted to abatement expenditures, residents can influence the pollution stock only by controlling tourist entries  $N_t$ . We are now ready to characterize the social optimum

### 3.1 The social optimum

The problem of the country is to maximize (3) under (7) and the resource constraint

$$C_t = \gamma_t N_t^{1-\theta} E_t^\phi \quad (8)$$

This is an optimal control problem with one state-variable  $E_t$  and two control variables ( $C$  and  $N$ ). However, one control variable can be eliminated by means of the previous budget constraint. The resulting optimal dynamic system is

$$\frac{\dot{N}_t}{N_t} = \frac{(\phi + \beta) \alpha N_t^\eta}{(1 - \theta) E_t} - \frac{\rho + m}{\eta} \quad (9)$$

$$\dot{E}_t = m(\bar{E} - E_t) - \alpha N_t^\eta \quad (10)$$

#### 3.1.1 Transitional dynamics and steady state analysis

We are interested in an equilibrium which implies sustainability for the stock of cultural, environmental and natural resources, i.e.,  $\dot{E} = 0$ . As we can easily see from (10),  $\dot{E} = 0$  implies  $\dot{N} = 0$ . The two equilibrium manifold  $\dot{N} = 0$  and  $\dot{E} = 0$  are given by

$$\dot{N} = 0 : N_1(E) = \left( \frac{(\rho + m)(1 - \theta)E}{\eta(\phi + \beta)\alpha} \right)^{\frac{1}{\eta}} \quad (11)$$

$$\dot{E} = 0 : N_2(E) = \left( \frac{m\bar{E} - mE}{\alpha} \right)^{\frac{1}{\eta}} \quad (12)$$

Existence and uniqueness are easily proved by a quick inspection of the geometrical properties of the two loci. They are two monotonic curves with positive

and negative inclination, respectively. Since  $N_2(E)$  has a positive vertical intercept, they intersect only once in the positive orthant of the  $(E, N)$  plane and the unique steady state is given by

$$E_{so} = \frac{m\eta(\phi + \beta)}{(\rho + m)(1 - \theta) + m\eta(\phi + \beta)} \bar{E} \quad (13)$$

$$N_{so} = \left( \frac{m}{\alpha} \frac{(\rho + m)(1 - \theta)}{(\rho + m)(1 - \theta) + m\eta(\phi + \beta)} \bar{E} \right)^{\frac{1}{\eta}} \quad (14)$$

As for stability, we can state the following

**Proposition 1** *The equilibrium  $(E_{so}, N_{so})$  is locally a saddle point for the system (9),(10)*

**Proof.** See the appendix. ■

The phase diagram looks as follows

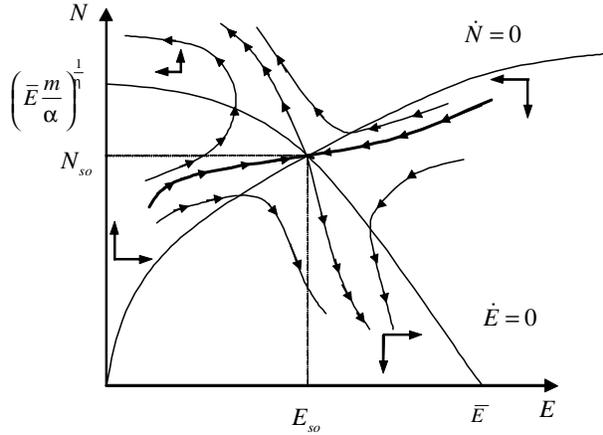


Fig. 1: Transitional dynamics in the case without abatement.

The characteristics of the transitional path towards the steady state deserves some comments.

First, notice that along the *lower* stable arm, both  $N$  and  $E$  increase overtime and eventually reach the stable equilibrium for  $t = \infty$ . Since consumption is a positive function of both the number of visitors ( $\theta < 1$ ) and of the environmental quality, consumption grows overtime as well along the lower stable arm. Finally, as a consequence, also instantaneous welfare is increasing along the

same manifold. On the other hand, along the *upper* stable arm, both  $N$  and  $E$  decrease overtime before reaching the steady state asymptotically and the same happen to consumption and welfare. If we take this model seriously and if we accept the idea that real world situations might be better interpreted in terms of transitional dynamics than with steady states configurations, some interesting remarks can be drawn. A country starting from an initial level belonging to the lower stable arm might be interpreted as a country whose optimal size of the tourist sector has not been reached yet. Think of a country who have discovered how to "employ" its environmental amenities for tourism purposes only recently. For such a country, the model predicts a relatively fast increase in the number of visitors per unit of time, joint with an increase of the environmental quality<sup>7</sup>. This positive and sustainable growth performance will last forever because the steady state is reached only for  $t = \infty$ , but its relative speed will decrease as the economy get closer to the steady state. According to this view, the well-known high-growth performance of many small open tourism economies need not to be interpreted as exogenous and equilibrium phenomenon as part of the literature on tourism tends to do (Lanza and Pigliaru 1994 and 2000, Nowak and Sahli, 2006), but rather as a temporary and transitional phenomenon with no need to invoke exogenous growth in the terms of trade<sup>8</sup>. Tourism development will eventually stop in the steady state, but such economies will reach this situation only asymptotically. This not-too-optimistic way to interpret this result, might be counterbalanced by a less pessimistic one: a country specialized in tourism, granted that it places itself along the saddle path, needs not deplete completely its environmental resources which, on the contrary, tends to a constant value. Hence, tourism specialization appears to be compatible with a sustainable use of the environmental resources. These observations lead us to a second important issue related to the transitional dynamics.

What the phase diagram is telling us is that, for any initial value of the environmental quality, there is one and only initial value of the number of tourists such that the country is able to place itself along one of the two stable arms. This is a typical feature of dynamic systems characterized by saddle point stability, where the dynamic path which tends to the unique steady state is represented by a manifold having measure zero with respect to the whole state space. Nonetheless, investigating the economic implications of this somewhat obvious observation can be highly instructing. It is clear from fig. 1 that if the country starts from an initial value of  $N$  which is too high with respect to the initial value of  $E$ , then it will not be able to move along the stable arm and, sooner or later, it will experience a fast growth in the number of visitors associated to a fast decrease of the environmental quality. This progressive reduction

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<sup>7</sup>It is not difficult to associate this situation to the case of many developing (mostly mediterranean) regions (such as Morocco, Tunisia, Egypt, Malta, Corse, etc) who have experienced a quite relevant increase in the number of visitors per year associated to a sharp increase in the gross national product. This increase in visitors doesn't seem to have compromised, so far, the beuties of their natural resources. On the contrary, it seems that the discovery of the "economic value" of the environment ( $\phi$  in our model) has determined a higher attention towards the environmental issues.

<sup>8</sup>It's easy to see that previous observations holds even if  $g = 0$ .

will lead, within a finite time, to a zero value of the environmental quality and therefore to a situation where both consumption and utility are null. In other words, this path is not sustainable. Then our model envisages the eventuality of a country experiencing a too fast and unbalanced tourism development which eventually leads to the death of the tourist destination. For such a country, both visitors and environmental quality will initially increase jointly, providing a growing welfare. But there comes a time when the number of visitors will be so high that the regenerative capacity of the environment is not sufficient to restore the pollution flow provoked by tourists inflows. Hence, within a finite interval of time environmental quality will start to decrease while the number of visitors continue to growth. Initially, this situation has ambiguous effects on welfare but these effects are progressively less ambiguous the more environmental quality approach to a zero value, which is associated to the death of the country. On the other hand, the model takes into account also the case of an economy which fails to employ its environmental amenities for tourism purposes and then its dynamic evolution ends up (within a finite time) with a perfectly virgin environment ( $E = \bar{E}$ ) but with no tourists at all and, therefore, with no consumption.

Finally, it is worth reflecting on the effect that (exogenous) growth might have on the variables  $C$ ,  $N$  and  $E$ . As already said, exogenous growth is introduced in this model by assuming that  $\gamma_t = \gamma_0 e^{gt}$  (where  $g \geq 0$  is the rate of growth of the WTP) and can be thought as the result of continual gains in the terms of trade<sup>9</sup>. By (13) and (14) we note that both tourist inflows  $N$  and the environmental quality  $E$  are not affected by  $\gamma_t$  so that they remain constant in steady state even if exogenous growth is introduced. It is worth noticing that this result still holds when a more general CES instantaneous utility is used in place of a logarithmic one<sup>10</sup> but, on the other hand, it is a direct consequence of the fact that the parameter  $\gamma$  enters the WTP in a multiplicative way. However, since steady state consumption is equal to  $C_{so} = \gamma_t N_{so}^{1-\theta} E_{so}^\theta$ , it grows at rate  $g$  and growing instantaneous utility in the long-run is obtained preserving both sustainability of the environment and constant number of visitors. In other words, an ever-increasing equilibrium price of the tourist services does not affect individuals' decision over the number of tourists to be hosted in the destination and the additional monetary resources are employed, date by date, in additional consumption. This result might have important policy implications since if we accept the conclusion according to which tourism specialization is associated with ever-increasing terms of trade, as suggested by both empirical, then specializing in tourism might allow for an ever-increasing welfare level in the long-run (which is an obvious consequence of the exogenous growth in the price of tourism) **without** compromising environmental sustainability and keeping the tourist inflows to a constant level.

<sup>9</sup>This approach is used, for example, by Rey-Maqueira et al. (2004).

<sup>10</sup>With CES utility the rate of growth  $g$  affects the *level* of  $n$  and  $E$ , but not their constancy in the steady state. Proof is available at request.

### 3.1.2 Comparative statics

The steady state level of the environmental quality: 1) increases with residents' environmental care ( $\frac{\partial E_{so}}{\partial \beta} > 0$ ); 2) increases (proportionally) with the maximum level of environmental quality ( $\frac{\partial E_{so}}{\partial E} > 0$ ); 3) increases with the natural rate of regeneration capacity ( $\frac{\partial E_{so}}{\partial m} > 0$ ); 4) decreases with impatience ( $\frac{\partial E_{ss}}{\partial \rho} < 0$ ); 5) increases with tourists' crowding aversion ( $\frac{\partial E_{so}}{\partial \theta} > 0$ ); 6) increases with tourists' care for environment ( $\frac{\partial E_{so}}{\partial \phi} > 0$ ) and, finally, 7) increases with the elasticity of the pollution flow with respect to tourists ( $\frac{\partial E_{so}}{\partial \eta} > 0$ ).

As for tourist inflows, they 1) decrease with care of the environment ( $\frac{\partial N_{so}}{\partial \beta} < 0$ ); 2) increase with the maximum level of environmental quality ( $\frac{\partial N_{so}}{\partial E} > 0$ ); 3) increase with the regeneration capacity ( $\frac{\partial N_{so}}{\partial m} > 0$ ); 4) decrease with the parameters related to the marginal impact on the dynamics of  $E$  ( $\frac{\partial N_{so}}{\partial \alpha} < 0$ ;  $\frac{\partial N_{so}}{\partial \eta} < 0$ ); 5) increase with impatience  $\frac{\partial N_{so}}{\partial \rho} > 0$ ; 6) decrease with tourists' aversion to crowd ( $\frac{\partial N_{so}}{\partial \theta} < 0$ ); 7) decrease with tourists' care for environment ( $\frac{\partial N_{so}}{\partial \phi} < 0$ ).

As for consumption, it is interesting to analyze its behavior with respect to environmental care  $\beta$ . A low level of  $\beta$  means a low level of  $E$  but a high level of  $N$ . As  $\beta$  grows, the effect on the tourist revenues (and therefore on consumption) is ambiguous: on the one hand, it allows for a higher steady state level of the environmental quality and therefore increases tourist revenues through an higher tourists' WTP. On the other, a higher  $\beta$  means a lower steady state level of  $N$  which reduces consumption. By calculations we find that there is a level of  $\beta^* = \frac{\rho \phi}{m}$  such that steady state consumption is maximized<sup>11</sup>. If  $\beta$  is low ( $\beta < \beta^*$ ), an increase in the love for the environment (e.g. as a result of campaigns to sensitize individuals) gives rise to an increase in consumption too. This is because, when  $E$  is very low, the marginal value that tourists will assign to the environment is very high so that their WTP grows significantly when  $E$  increases. This is what happens when  $\beta$  grows starting from very low values. As long as this positive effect of an increase in  $\beta$  is larger (in absolute term) than the negative effect of  $\beta$  on  $N_{so}$ , there will be an increase in tourist expenditures and therefore in consumption too. The relationship reverses when a further increase in  $\beta$  leads to a value of  $E$  such that the increase in tourists' WTP is not able to compensate any longer for the reduction in the number of tourists. In other words, our model suggests us that too much love for environment means low consumption levels but, on the other hand, an increase in the environmental

<sup>11</sup>The same level of  $\beta$  represents instead a maximum when steady state consumption is considered as a function of impatience  $\rho$ :

$$\frac{\partial c_{ss}}{\partial \rho} \begin{cases} > 0 \text{ for } \beta < \frac{\phi \rho}{m} = \beta_{so}^{gr} \\ < 0 \text{ for } \beta > \frac{\phi \rho}{m} = \beta_{so}^{gr} \end{cases}$$

So that an increase in impatience  $\rho$  may give rise to a higher consumption in the steady state if the love for the environment is sufficiently high.

care might lead to an increase in consumption. Hence, we obtain a sort of golden rule level of  $\beta$  with respect to consumption.

## 3.2 Solution with externalities and corrective policies

Whenever a direct intervention of the social planner is not possible, the non-excludable nature of the environmental quality joint with the high dependence of tourism revenues on foreign visitors' preference may activate some externalities which prevents the decentralized solution to be optimal. These situations require the investigation of the proper tax design able to create incentives which induce agents to replicate the social optimum. In what follow we will briefly analyse and discuss these issues with respect to two different and partially related kinds of externalities: 1) a typical "tragedy of the commons" externality, according to which each single agent does not perceive completely its contribution in determining the aggregate number of tourists hosted in the country at time  $t$ ; 2) an "information" externality, according to which agents are not aware of tourists' preferences and therefore they do not take into account that their decisions over the number of tourists to be hosted can negatively influence foreigners' willingness to pay either directly (tourists are crowding-averse) or indirectly (through the stock of environmental resources).

### 3.2.1 "Tragedy of the commons" externality

In order to capture the effect of this kind of externality, we consider a decentralized version of our economy. We then assume the economy is made up of a large number of competing "household-firms", which we normalize to 1. Each of them chooses the number of tourists  $n_t$  to be hosted at any time  $t$  in order to maximize her lifetime utility. Each single choice of  $n_t$  concurs to determine the aggregate number of tourists  $N_t$ . The idea typical of the "tragedy of the commons" literature is formalized by adopting an approach similar to Soretz (2003) and Smulders and Gradus (1996). We assume that agents do not perceive completely their contribution in determining the aggregate number of visitors at any time  $t$ . The extent to which each household-firm perceives the aggregate number of tourists  $N_t$  to depend on her single decision is parametrized by  $\delta \in [0, 1]$ . Hence, for each household the aggregate number of tourists at any time  $t$  is given by  $n_t^\delta N_t^{1-\delta}$ .

In equilibrium the aggregate number of tourists equals individual choice of  $n$  because households are identical and the population size is normalized to 1.  $\delta = 1$  represents perfect knowledge about the effect of individual  $n$  on aggregate  $N$ . On the other hand  $\delta = 0$  is associated with a situation where the representative household neglects completely his individual contribution to the aggregate number of tourists. As a consequence, pollution flow (which depends on  $N$ ) is perceived not to depend in anyway on individual choices. It's easy to conclude that, in the latter case, the rational individual choice would be that of hosting an infinite number of tourists with the obvious consequence that environmental quality, and therefore consumption, immediately shrinks to zero.

Each single household solves the following problem

$$\begin{aligned} & \max_{(c,n)} \int_0^{\infty} [\ln c_t + \beta \ln E_t] e^{-\rho t} dt & (15) \\ \text{s.t.} \quad & \dot{E}_t = m(\bar{E} - E_t) - n_t^{\alpha\delta} N_t^{\alpha(1-\delta)} \quad \text{and} \quad c_t = n_t \gamma_t E_t^{\phi} (n_t^{\delta} N_t^{1-\delta})^{-\theta} \end{aligned}$$

The resulting dynamic system for the aggregate economy is given by

$$\frac{\dot{N}}{N} = \frac{(\phi + \beta) \alpha \delta N_t^{\eta}}{(1 - \theta \delta) E_t} - \frac{\rho + m}{\eta} \quad (16)$$

$$\dot{E} = m(\bar{E} - E_t) - \alpha N_t^{\eta} \quad (17)$$

Notice that the difference with respect to the social optimum lies only in the dynamics of  $N$ , while the motion equation for  $E$  remains the same.

The transitional dynamics displays the same qualitative behaviour as before, except that the  $\dot{N} = 0$  isocline is steeper. As a consequence, the two isoclines intersect for an higher value of the number of tourists and for a lower value of the environmental quality.

$$E_{tc} = \frac{m\eta(\phi + \beta)\alpha\delta}{(\rho + m)(1 - \theta\delta) + m\eta(\phi + \beta)\alpha\delta} \bar{E} < E_{so} \quad (18)$$

$$N_{tc} = \left( \frac{m(\rho + m)(1 - \theta\delta)}{(\rho + m)(1 - \theta\delta) + m\eta(\phi + \beta)\alpha\delta} \bar{E} \right)^{\frac{1}{\eta}} > N_{so} \quad (19)$$

**Corrective policy** In order to reduce tourists inflows and then increase steady-state level of environmental stock, local authorities cannot rely on a direct tax on foreign tourists (a so-called "tourist tax") because we have assumed perfectly elastic foreign demand for tourist services so that tourism revenues shrink to zero for any price level different from tourists' WTP. However, this setting allows for a very simple first-best policy scheme: local authorities can tax income and then simply redistribute the tax gains with ex-post lump-sum transfers. Accordingly, by properly taxing the residents, local authorities induce them to choose the optimal level of visitors and, by ex-post compensating the latter, it allows individuals to reach the maximum steady state welfare level. Moreover, since this corrective tax policy brings the level of tourists inflows and of the environmental asset back to the optimal value, it also increases tourists' WTP and then it basically works as an "implicit tourist tax" on foreigners.

The government's budget balance is given by  $\tau_{tc} \gamma_t N_t^{1-\theta} E_t^{\phi} = v_t$  where  $\tau_{tc}$  is the tax rate on residents' income and  $v_t$  is the lump-sum transfer.

The problem is similar to (15) except that now the budget constraint of each single household-firm is given by

$$c_t = (1 - \tau_{tc}) \gamma_t E_t^{\phi} n_t^{1-\theta\delta} N_t^{-\theta(1-\delta)} + v_t \quad (20)$$

where  $N_t$  and  $v_t$  are taken as given.

The aim of government tax is to induce residents to reduce the number of foreign tourists to be hosted because the tax reduces the marginal utility of  $n$  with respect to the no-tax case. More precisely, the "perceived" marginal utility of tourists inflows is now equal to  $u_n = \frac{(1-\theta\delta)(1-\tau_{tc})}{n}$ , while in the no-tax case it was  $\frac{1-\theta\delta}{n}$ .

The resulting dynamic system for the aggregate economy is

$$\frac{\dot{N}}{N} = \frac{(\phi(1-\tau_{tc}) + \beta)\alpha\delta N_t^\eta}{(1-\theta\delta)(1-\tau_{tc})E_t} - \frac{\rho + m}{\eta} \quad (21)$$

$$\dot{E} = m(\bar{E} - E_t) - \alpha N_t^\eta \quad (22)$$

As it can easily be observed, the accumulation equation of  $E$  is not influenced so that the aim of the CP is simply to find a tax rate such that the transitional dynamics of  $N$  coincides with the social optimum. The optimal tax rate  $\tau_{tc}^*$  which satisfies this condition is the following<sup>12</sup>

$$\tau_{tc}^* = 1 - \frac{\delta\beta(1-\theta)}{\phi(1-\delta) + \beta(1-\delta\theta)} \quad (23)$$

Given that

$$\frac{\partial\tau_{tc}^*}{\partial\phi} > 0; \frac{\partial\tau_{tc}^*}{\partial\theta} > 0; \frac{\partial\tau_{tc}^*}{\partial\beta} < 0; \frac{\partial\tau_{tc}^*}{\partial\delta} < 0$$

the higher the degree of the externalities ( $\phi$  and  $\theta$ ) and the lower the residents' environmental care, the higher the tax must be. And, obviously, the higher the degree of "sense of responsibility", the lower the tax rate. When  $\delta = 1$ , the optimal tax is zero because the decentralized solution coincides with the command optimum.

### 3.2.2 Information externality

In some cases local authorities are much better informed about tourists' preferences than individual tourist operators. Local authorities might commission apposite inquiries or have knowledge of studies which are unknown to private operators. In these cases, it might be appropriate to assume that, in the unregulated economy, each single agent takes tourists preferences as given and therefore she doesn't realize that her own actions actually affect visitors' WTP<sup>13</sup>. This externality is of a distinct kind with respect to the "tragedy of the commons" one and therefore we assume  $\delta = 1$  (perfect sense of responsibility) in order to focus on the effect of the information externality only.

Each single household solves the following problem

<sup>12</sup>It is worth to highlight that this tax rate is meant to be "optimal" not only in the steady-state but along each trajectory of the system (21), (22).

<sup>13</sup>The dynamic effect of the same externality has been investigated, in a different framework, by Rey-Maqueira et al. (2004).

$$\begin{aligned} & \max \int_0^{\infty} [\ln c_t + \beta \ln E_t] e^{-\rho t} dt & (24) \\ \text{s.t.} & : \dot{E} = m(\bar{E} - E_t) - \alpha n_t^\eta, c_t = n_t \gamma_t p(E_t, n_t) \end{aligned}$$

where now  $p(E_t, n_t)$  is given.

The resulting dynamic system for the aggregate economy is given by

$$\frac{\dot{N}}{N} = \frac{\alpha \beta N_t^\eta}{E_t} - \frac{\rho + m}{\eta} \quad (25)$$

$$\dot{E} = m(\bar{E} - E_t) - \alpha N_t^\eta \quad (26)$$

Once again, the transitional dynamics displays the same qualitative properties of the command optimum and, similarly to the case of the "tragedy of the commons", the main difference relies in the fact that the  $\dot{N} = 0$  is steeper than what it should be to be optimal. Then again, in the steady state, environmental quality is lower and the number of visitors is higher than in the optimal solution.

$$E_{ie} = \frac{\eta \beta m}{\rho + m + \eta m \beta} \bar{E} < E_{so} \quad (27)$$

$$N_{ie} = \left( \frac{m}{\alpha} \frac{\rho + m}{\rho + m + m \beta \eta} \bar{E} \right)^{\frac{1}{\eta}} > N_{so} \quad (28)$$

It is worth to highlight that, in this case, steady state values for  $E$  and  $N$  are not functions of the parameters which affects tourists' preferences ( $\phi$  and  $\theta$ ). As a consequence, when  $\beta = 0$  (residents don't care about the environment), the environmental quality shrinks to zero because agents don't recognise its intrinsic economic value.

**Corrective policy** The policy needed induce people to replicate the optimal dynamic system described by (9) and (10) is identical to the previous case: local authorities can tax income and then simply redistribute the tax gains with ex-post lump-sum transfers. The resulting dynamic system for the whole economy is now given by

$$\frac{\dot{N}}{N} = \frac{\alpha \beta N_t^\eta}{(1 - \tau_{ie}) E_t} - \frac{\rho + m}{\eta} \quad (29)$$

$$\dot{E} = m(\bar{E} - E_t) - \alpha N_t^\eta \quad (30)$$

where  $\tau_{ie}$  is the income tax rate in the information externality case. Again, the optimal tax rate which corrects the dynamics of the number of tourists  $\dot{N}$  is given by

$$\tau_{ie}^* = \frac{\phi + \beta \theta}{\phi + \beta} \quad (31)$$

Given that

$$\frac{\partial \tau_{ie}^*}{\partial \phi} > 0; \frac{\partial \tau_{ie}^*}{\partial \theta} > 0; \frac{\partial \tau_{ie}^*}{\partial \beta} < 0$$

this optimal tax rate depends on the same parameters as the previous one and changes in the same directions (except for  $\delta$  which is assumed to be equal to 1). Moreover, as in the previous case, if the government applies a tax  $\tau^*$  on residents' income, tourists are willing to pay more to visit the destination. Hence part of the tax burden shifts from residents to tourists.

## 4 A model with abatement expenditures

In the following sections we analyse, discuss and compare the model's results in the most general case when employing resources in the abatement industry is an effective way to reduce pollution ( $P_a < 0$ ). In this case, the country may have incentives to dedicate part of the national income to abatement efforts. A distinctive and crucial feature of pollution abatement is that model's results are highly sensitive with respect to the particular form that pollution abatement technology displays inside the accumulation equation for the environmental quality. In this paper, we make use of the most standard form in the environmental and growth literature<sup>14</sup>, which can be found for example in Smulders and Gradus (1996) and in Stokey (1998):

$$P(a, N) = \frac{\alpha N^\eta}{\psi a^\mu}; \quad \eta > \mu > 0; \quad \psi > 0 \quad (32)$$

It is important to emphasize that, according to this formula, tourists' impact on pollution is infinite when abatement efforts are null ( $\lim_{a \rightarrow \infty} P = \infty$ ). This apparently extreme assumption might be better justified if we interpret abatement expenditure in broad terms. Indeed, local authorities always dedicate resources to some kind of activities aiming at reducing the negative marginal impact of tourists.

### 4.1 Social optimum

The problem of the country is now to choose the optimal level of consumption  $C_t$ , the optimal level of tourists to be hosted  $N_t$  and the optimal abatement tax rate  $z_t$  in order to maximize residents' welfare:

$$\begin{aligned} \max_{(C_t, N_t, z_t)} U_t &= \int_0^\infty (\ln C_t + \beta \ln E_t) e^{-\rho t} dt & (33) \\ \text{s.t.} \quad \dot{E} &= m(\bar{E} - E_t) - \frac{\alpha N_t^\eta}{\psi a_t^\mu}, \quad C_t = \gamma_t E_t^\phi N_t^{1-\theta} - a_t, \quad a_t = z_t \gamma_t E_t^\phi N_t^{1-\theta} \end{aligned}$$

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<sup>14</sup>The implications of different kinds of abatement technology are analysed in Cerina (2006).

where  $z_t \in (0, 1)$  is the abatement tax rate, that is, the fraction of income devoted to abatement expenditures.

By equating the first-order conditions we get

$$z_t = \frac{\mu(1-\theta)}{\eta} = \bar{z} \quad (34)$$

Hence we find that the optimal tax rate the government should impose on residents is constant along every optimal trajectory, being a function of three constant parameters. In particular, the optimal tax rate is a positive function of the elasticity of pollution with respect to the abatement effort  $a\left(\frac{\partial z}{\partial \mu} > 0\right)$ , a negative function of visitors' crowding aversion ( $\frac{\partial z}{\partial \theta} < 0$ , the more tourists are crowding adverse, the less tourists is optimal to host in the country and therefore the less is the damage they bring to the environment) and a negative function of the elasticity of pollution with respect to the number of tourists ( $\frac{\partial z}{\partial \eta} < 0$ ). Notice that the behaviour of optimal abatement tax rate follows the behaviour of marginal value of  $N$  in the hamiltonian. In particular, this value is negatively affected by  $\eta$  (the higher the damage of tourists, the less their economic value is), positively affected by  $\mu$  (the higher the productivity of abatement, the lower the "effective" marginal impact of tourists and, hence, the higher their economic value) and negatively affected by  $\theta$  (the higher tourists' aversion to crowding, the lower their economic value).

The economy is therefore completely described by the following dynamic system

$$\frac{\dot{N}}{N} = \frac{(\phi + \beta)}{(1-\theta)} \frac{\alpha N_t^{\eta-\mu(1-\theta)}}{\psi \bar{z}^\mu \gamma_t^\mu E_t^{1+\mu\phi}} + \frac{\phi \mu m}{\eta - \mu(1-\theta)} \frac{(\bar{E} - E_t)}{E} + \frac{\mu g - \rho - m}{\eta - \mu(1-\theta)} \quad (35)$$

$$\dot{E} = m(\bar{E} - E_t) - \frac{\alpha N_t^{\eta-\mu(1-\theta)}}{\psi \bar{z}^\mu \gamma_t^\mu E_t^{\mu\phi}} \quad (36)$$

where  $\bar{z}$  is identified by (34).

## 4.2 Transitional dynamics and steady state analysis

If we compare the (35) and (36) with (9) and (10) (the latter describing the evolution of the economy in the no-abatement case), we find that both  $\dot{E}$  and  $\dot{N}$  depends now on  $\gamma_t$  which is increasing overtime by assumption. In particular, it can be easily shown that the sustainability condition  $\dot{E} = 0$  requires a growing number of tourists in the steady state. By equating (36) to zero and by differentiating it with respect to time we find that

$$\dot{E} = 0 \Leftrightarrow \frac{\dot{N}}{N} = \frac{\mu g}{\eta - \mu(1-\theta)} \geq 0.$$

Then, unlike the case without abatement expenditures, exogenous growth in the WTP also affects positively the steady state rate of growth of  $N$ . This

is due to the fact that when WTP grows, also tourism revenues grows and therefore, at each date, more and more resources are devoted to abatement. As a consequence, even the carrying capacity of visitors, i.e. the number of tourists which exactly compensate for the regenerative capacity of the environment, grows overtime. The steady-state growth rate of  $N$  is positively affected by the exogenous growth rate of the terms of trade ( $g$ ) and by the measure of the productivity of abatement ( $\mu$ ) while it is negatively affected by the measure of the negative impact of tourists on the environment  $\eta$ .

An ever-growing number of tourists is a result which might be difficult to accept once we consider that the limited amount of physical space might be a good reason for an upper bounded accommodation capacity within a country. However, 1) this conclusion is consistent with the data and the mechanism on which it relies might represent an alternative explanation for the observed increasing number of tourists worldwide (WTO, 2006); 2) there are some other works using a dynamic setting (such as Papatheodoru, 2003) where ever-increasing number of visitors is introduced as an assumption and justified by the observed non-stationary patterns of tourists worldwide.

Since  $N$  grows constantly in steady state, it is convenient to work with a new variable that is constant in steady state. Hence we define the variable  $\tilde{N} = N_t e^{-\frac{\mu g}{\eta - \mu(1 - \theta)} t}$  called "effective" number of tourists per unit of time  $t$  such that the proper dynamic system to analyse the transitional dynamics is given by

$$\frac{\dot{\tilde{N}}}{\tilde{N}} = \frac{(\phi + \beta)}{(1 - \theta)} \frac{\alpha \tilde{N}_t^{\eta - \mu(1 - \theta)}}{\psi \bar{z}^\mu \gamma_0 E_t^{1 + \mu\phi}} + \frac{\phi \mu m \frac{\bar{E} - E_t}{E_t} - (\rho - m)}{\eta - \mu(1 - \theta)} \quad (37)$$

$$\dot{E} = m(\bar{E} - E_t) - \frac{\alpha \tilde{N}_t^{\eta - \mu(1 - \theta)}}{\psi \bar{z}^\mu \gamma_0 E_t^{\mu\phi}} \quad (38)$$

Equilibrium manifolds are

$$\dot{\tilde{N}} = 0 : \tilde{N}_1(E) = \left( \frac{(1 - \theta) \psi \bar{z}^\mu \gamma_0 E_t^{1 + \mu\phi}}{\alpha (\phi + \beta) (\eta - \mu(1 - \theta))} \left( \rho - m - \phi \mu m \frac{\bar{E} - E_t}{E_t} \right) \right)^{\frac{1}{\eta - \mu(1 - \theta)}} \quad (39)$$

$$\dot{E} = 0 : \tilde{N}_2(E) = \left( \frac{(m\bar{E} - mE_t) \psi \bar{z}^\mu \gamma_0^\mu E_t^{\mu\phi}}{\alpha} \right)^{\frac{1}{\eta - \mu(1 - \theta)}} \quad (40)$$

Unlike the no-abatement case, both the equilibrium manifolds are now represented by bell-shaped curves having opposite concavity with respect to the origin. Because of their geometrical form, they intersect only once in the positive orthant of the  $(E, N)$  state space, so the steady state is unique and is given by

$$E_{aso} = \frac{m\eta(\phi + \beta) - m\beta\mu(1 - \theta)}{(\rho + m)(1 - \theta) + m\eta(\phi + \beta) - m\beta\mu(1 - \theta)} \bar{E} \quad (41)$$

$$\tilde{N}_{aso} = \left( \frac{m\psi\bar{z}^\mu\gamma_0^\mu}{\alpha} (\bar{E} - E_{sa}) E_{sa}^{\mu\phi} \right)^{\frac{1}{\eta - \mu(1 - \theta)}} \quad (42)$$

As for stability, we can state the following

**Proposition 2** *The equilibrium  $(E_{aso}, N_{aso})$  is locally a saddle point for the system (37),(38)*

**Proof.** See the appendix. ■

The phase diagram doesn't look so different with respect to the no-abatement case

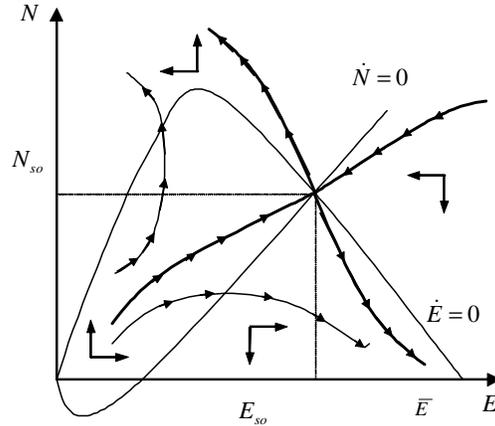


Fig. 2: Transitional dynamics in the case with abatement.

We can easily observe that, apart from the growing number of tourists in the steady state, the transitional dynamics displays similar qualitative properties with respect to the no-abatement case, so that the previous arguments applies here also.

As for the steady state values we note that, quite surprisingly, environmental quality is lower than in the no-abatement case. This apparently counterintuitive result can be easily understood by taking a look at the expression (13) of the steady state value of  $E$  in the no-abatement case. In the latter case we have that  $\frac{\partial E_{so}}{\partial \eta} > 0$  because an increase in the elasticity of pollution with respect to

visitors, which represents a measure of the environmental damage of tourists, lowers the marginal value of tourists in the hamiltonian, so that it is optimal to reduce its number. As a consequence, steady state environmental quality increases with  $\eta$ . When abatement is available, it allows for a reduction of the elasticity pollution with respect to tourists  $\left(\frac{\partial P/P}{\partial N/N}\right)$  so that now we have  $\eta - \mu(1 - \theta)$  whereas in the no-abatement case we had  $\eta$ . Hence  $\frac{\partial E_{aso}}{\partial(\eta - \mu(1 - \theta))} > 0$  and then  $\frac{\partial E_{aso}}{\partial \mu} < 0$ . In other words, as the productivity of abatement increase, the social planner finds it optimal to increase the number of tourists at the expenses of the environment.

### 4.3 Solution with externalities and optimal policies

We now consider the decentralized version of our economy and we apply the same analysis we have developed in the no-abatement case. In particular, we calculate the model's solution for the two kinds of market failures introduced before and we find the optimal policy design for both cases. In what follows, we assume that abatement expenditures remain public (i.e. the pollution abatement technology is available to local authorities only) and the abatement tax rate is set at the optimal level  $\bar{z} = \frac{\mu(1 - \theta)}{\eta}$ .

#### 4.3.1 "Tragedy of the commons" externality and corrective policy

We assume that agents do not perceive completely their contribution in determining the aggregate number of visitors at any time  $t$ . The extent to which each household-firm perceives the aggregate number of tourists  $N_t$  to depend on her single decision is parametrized by  $\delta \in [0, 1]$ . Hence, for each household the aggregate number of tourists at any time  $t$  is given by  $n_t^\delta N_t^{1 - \delta}$ .

Each single household-firm maximizes its lifetime utility taking  $N_t$ , abatement expenditures  $a_t$  and abatement tax  $\bar{z}$  as given. Again, the resulting transitional dynamics displays similar features with respect to the previous cases. The only difference relies on the dynamics of the effective number of tourists

$$\frac{\dot{\tilde{N}}}{\tilde{N}} = \left( \frac{\delta\eta(\phi + \beta) - \phi\mu(1 - \theta\delta)}{(1 - \theta\delta)(\eta - \mu(1 - \theta))} \right) \frac{\alpha\tilde{N}_t^{\eta - \mu(1 - \theta)}}{\psi\bar{z}^\mu\gamma_0^\mu E_t^{1 + \mu\phi}} + \frac{\phi\mu m \frac{\bar{E} - E_t}{E_t} - (\rho - m)}{\eta - \mu(1 - \theta)} \quad (43)$$

which leads to an excessive number of "effective" tourists and a too low level of environmental quality in the steady state. In order to correct this market failure the government may act in a similar manner with respect to the no-abatement case: it should introduce an additional tax on (gross) income whose revenues are successively redistributed lump-sum. Each household-firm then solves the following problem

$$\max_{(c,n)} \int (\ln c_t + \beta \ln E_t) e^{-\rho t} dt \quad (44)$$

$$\begin{aligned} \text{s.t.} \quad & \dot{E}_t = m(\bar{E} - E_t) - \frac{(n_t^\delta N_t^{1-\delta})^\eta}{a_t^\mu}, \quad c_t = (1 - \tau_{atc} - \bar{z}) \gamma_t E_t^\phi n_t^{1-\theta\delta} N_t^{-\theta(1-\delta)} + v_t, \\ & v_t = \tau_{atc} \gamma_t E_t^\phi n_t^{1-\theta\delta} N_t^{-\theta(1-\delta)}, \quad a_t = \bar{z} \gamma_t E_t^\phi n_t^{1-\theta\delta} N_t^{-\theta(1-\delta)} \end{aligned}$$

where  $v_t, a_t, \bar{z}$  and  $N_t$  are taken as given and  $\tau_{atc}$  is the additional tax rate on income.

This policy does not affect the accumulation equation for  $E$ , while the resulting dynamics for  $\tilde{N}$  is given by

$$\frac{\dot{\tilde{N}}}{\tilde{N}} = \left( \frac{\delta \eta \left( \frac{(\phi+\beta)(1-\bar{z})-\phi\tau_{atc}}{(1-\bar{z}-\tau_{atc})} \right)}{(1-\theta\delta)(\eta-\mu(1-\theta))} - \phi\mu \right) \frac{\alpha \tilde{N}_t^{\eta-\mu(1-\theta)}}{\psi \bar{z}^\mu \gamma_0 E_t^{1+\mu\phi}} + \frac{\phi\mu m \frac{(\bar{E}-E_t)}{E_t} - (\rho-m)}{\eta-\mu(1-\theta)} \quad (45)$$

The optimal tax rate  $\tau_{atc}^*$  which equates the previous dynamic with the optimal one expressed by (35) is<sup>15</sup>

$$\tau_{atc}^* = 1 - \frac{\mu(1-\theta)}{\eta} - \frac{\beta\delta(1-\theta)(\eta-\mu(1-\theta))}{\beta(1-\theta\delta)(\eta-\mu(1-\theta)) + \eta\phi(1-\delta)} \quad (46)$$

The behaviour of this optimal tax rate reflects the behaviour of the respective optimal tax rate in the no-abatement case ( $\tau_{tc}^*$ ) as far as the parameters  $\phi, \delta, \theta$  and  $\beta$  are concerned. In particular,

$$\frac{\partial \tau_{atc}^*}{\partial \delta} < 0; \quad \frac{\partial \tau_{atc}^*}{\partial \beta} < 0; \quad \frac{\partial \tau_{atc}^*}{\partial \phi} > 0; \quad \frac{\partial \tau_{atc}^*}{\partial \theta} > 0$$

However, unlike  $\tau_{tc}^*$ ,  $\tau_{atc}^*$  is also affected by the parameters  $\eta$  and  $\mu$ . The way this parameters affect  $\tau_{atc}^*$  is ambiguous<sup>16</sup>

It is interesting to note that, in this case, the total taxation ( $\tau_{atc}^* + \bar{z} = 1 - \frac{\delta\beta(1-\theta)(\eta-\mu(1-\theta))}{\beta(1-\theta\delta)(\eta-\mu(1-\theta)) + \eta\phi(1-\delta)}$ ) is lower than in the no-abatement case where  $\tau_{tc}^* = 1 - \frac{\delta\beta(1-\theta)}{\beta(1-\theta\delta) + \phi(1-\delta)}$ . In other words, the presence of public abatement reduces the distortions associated to the excessive use of the common resource  $E$ . If we focus on total taxation, then the role of  $\eta$  and  $\mu$  is not ambiguous at all being  $\frac{\partial(\tau_{atc}^* + \bar{z})}{\partial \eta} < 0$  and  $\frac{\partial(\tau_{atc}^* + \bar{z})}{\partial \mu} > 0$ . In words, the total optimal tax rate ( $\tau_{atc}^* + \bar{z}$ ) decreases with the intensity of the visitors' damage on the environment and increases with the effectiveness of abatement.

<sup>15</sup>Notice that if  $\mu = 0$ , the expression for  $\tau_{atc}^*$  collapses to  $\tau_{tc}^*$ .

<sup>16</sup>We have

$$\begin{aligned} \frac{\partial \tau_{atc}^*}{\partial \eta} &= \frac{\mu(1-\theta)}{\eta} - \frac{\beta\delta(1-\theta)\phi(1-\delta)\mu(1-\theta)}{(\beta(1-\theta\delta)(\eta-\mu(1-\theta)) + \eta\phi(1-\delta))^2} \\ \frac{\partial \tau_{atc}^*}{\partial \mu} &= -\frac{(1-\theta)}{\eta} + \frac{\beta\delta(1-\theta)\eta\phi(1-\delta)(1-\theta)}{(\beta(1-\theta\delta)(\eta-\mu(1-\theta)) + \eta\phi(1-\delta))^2} \end{aligned}$$

### 4.3.2 Information externality

As in the no-abatement case, we also consider the situation when agents are not informed about tourists' preferences. As in the no-abatement case, we assume  $\delta = 1$  so that the effect of the "tragedy of the commons" externality is neutralized. Each single household-firm maximizes its lifetime utility taking tourists' WTP, abatement expenditures  $a_t$  and abatement tax  $\bar{z}$  as given. Again, there are no significant differences in the resulting transitional dynamics which displays similar qualitative behaviour with respect to the previous cases. Therefore we go straight to the effects of the corrective policy design, which is the same as the one implemented in the "tragedy of the commons" case. As usual, the dynamics of  $E$  remains unchanged while the resulting dynamics of  $\tilde{N}$  is given by

$$\frac{\dot{\tilde{N}}}{\tilde{N}} = \left( \frac{\beta(1-\bar{z})\eta}{(1-\tau_{aie}-\bar{z})} - \phi\mu \right) \frac{\alpha\tilde{N}_t^{\eta-\mu(1-\theta)}}{\psi\bar{z}^\mu\gamma_0^\mu E_t^{1+\mu\phi}} + \frac{\phi\mu m \frac{\bar{E}-E_t}{E_t} - (\rho-m)}{\eta-\mu(1-\theta)} \quad (47)$$

where  $\tau_{aie}$  is the additional tax rate on tourism revenues. As usual, the government chooses the particular tax rate which is able replicate the optimal dynamics of  $\tilde{N}$ , expressed in (35). This optimal tax rate is given by<sup>17</sup>

$$\tau_{aie}^* = \frac{\beta\theta(\eta-\mu(1-\theta)) + \eta\phi}{\beta(\eta-\mu(1-\theta)) + \eta\phi} - \frac{\mu(1-\theta)}{\eta} \quad (48)$$

Analogously to the no-abatement case, we have

$$\frac{\partial \tau_{aie}^*}{\partial \beta} < 0; \quad \frac{\partial \tau_{aie}^*}{\partial \phi} > 0; \quad \frac{\partial \tau_{aie}^*}{\partial \theta} > 0$$

Similarly to the tragedy of the commons case, the optimal tax rate is now also ambiguously affected by  $\eta$  and  $\mu$ .<sup>18</sup> This ambiguity is once again canceled out if we consider total tax rate ( $\tau_{aie}^* + \bar{z}$ ) instead of  $\tau_{aie}^*$  only. In particular, the signs of the derivatives with respect to  $\eta$  and  $\mu$  are the same as in the "tragedy of the commons" case

$$\frac{\partial (\tau_{api}^* + \bar{z})}{\partial \eta} < 0; \quad \frac{\partial (\tau_{api}^* + \bar{z})}{\partial \mu} > 0$$

However and interestingly enough, unlike the previous case here the total tax rate  $\left( \tau_{aie}^* + \bar{z} = \frac{\beta\theta(\eta-\mu(1-\theta)) + \eta\phi}{\beta(\eta-\mu(1-\theta)) + \eta\phi} \right)$  is higher with respect to the no-abatement case  $\left( \tau_{ie}^* = \frac{\beta\theta + \phi}{\beta + \phi} \right)$ . In other words, the presence of abatement increases the distortion introduced by the unawareness of tourists' preferences.

<sup>17</sup> Again, notice that for  $\mu = 0$  we have  $\tau_{aie}^* = \tau_{ie}^*$ .

<sup>18</sup> We have  $\frac{\partial \tau_{api}^*}{\partial \eta} = \frac{\mu(1-\theta)}{\eta^2} - \frac{\beta(1-\theta)\phi\mu(1-\theta)}{(\beta(\eta-\mu(1-\theta)) + \eta\phi)^2}$  and  $\frac{\partial \tau_{api}^*}{\partial \mu} = -\frac{(1-\theta)}{\eta} + \frac{\eta\phi(1-\theta)\beta(1-\theta)}{(\beta(\eta-\mu(1-\theta)) + \eta\phi)^2}$

## 5 Conclusions

The positive growth performance of small open economies specialized in tourism poses interesting questions regarding the role that environmental resources play in the long term prospects of such countries and in the sustainability and efficiency of their process of development. Our paper presents a simple analytical framework where some of these questions can start to be answered properly. We have built a dynamic general equilibrium model where a small open economy specialized in tourism based on environmental resources has to choose the number of tourists to be hosted, the level of consumption and the fraction of income to be devoted to abatement efforts in order to maximize the long-run welfare of its residents by taking into account the several dynamic trade-offs associated to this choice. We have analysed the dynamic properties of the model in two different versions, with and without abatement expenditures and in both versions a unique steady-state is found to be a saddle point. The analysis of the transitional dynamics allows us to provide an alternative and "out-of-equilibrium" interpretation for some stylized facts that the literature tends to explain as equilibrium phenomenon. As a consequence of our particular setup, growth cannot be sustained in the long-run by any *endogenous* factor but the presence of exogenous growth in the terms of trade allows for an increasing consumption in the long-run without compromising environmental sustainability. Only when public abatement is allowed, exogenous growth in the terms of trade, by raising the carrying capacity at any date, also leads to constant increase in the number of visitors in the long-run. As a counterpart, steady state environmental quality is reduced when abatement technology is available, so that agents prefers to raise the number of tourists at the expenses of the environmental quality.

Finally, we have analysed the issue of market failures by taking into account the implications of two kinds of externality: 1) a typical "tragedy of the commons" situation, suggested by the non-excludable nature of the environmental good; 2) an "informational" externality according to which agents are not aware of tourists' preferences. We have solved the model for both kinds of externalities and with or without abatement expenditures, comparing the steady-state properties with the respective social optimum solutions. We have implemented the proper corrective policy design and we have found the closed-form solution for the optimal tax rate able to induce the unregulated economy to replicate the social optimum transitional dynamics. The policy design we have proposed differs from those actually implemented in some Mediterranean regions (such as Sardinia and Corsica) because in our model taxes are not paid by tourists but by residents. However, insofar it leads to an increase in a tourist's willingness to pay, our corrective policy always works as an "implicit tourist tax" paid by foreign tourists who are, on the other hand, compensated with a better quality of the service purchased. Finally, the presence of public abatement is found to reduce the total fraction of income taxed in the "tragedy of the commons" case while it would raise total fiscal incidence in the case of the "informational" externality. Although the model presented is very stylized, we believe it raises interesting policy implications and provides informations about the role of en-

vironment in the development of the tourist sector. These informations can be useful for policymakers who are facing the choice between investing their resources in tourism or in more high-intensive technology sectors.

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## A Proof of proposition 1

Linearizing the system (9),(10) around the unique steady state we yield

$$\begin{bmatrix} \dot{n} \\ \dot{E} \end{bmatrix} = J \begin{bmatrix} n - n_{ss} \\ E - E_{ss} \end{bmatrix}$$

where

$$J = \begin{bmatrix} \rho + m_0 & -\frac{(\rho+m_0)^2}{\beta} \\ -\alpha & -m_0 \end{bmatrix}$$

So that

$$\det J = -m_0(\rho + m_0) - \frac{(\rho + m_0)^2}{\alpha\beta} < 0$$

So the unique steady state is locally a saddle■

## B Proof of proposition 2

Linearizing the system (35),(36) around the unique steady state we yield

$$\begin{bmatrix} \dot{\tilde{N}} \\ \dot{\tilde{E}} \end{bmatrix} = J \begin{bmatrix} \dot{\tilde{N}} \\ \dot{\tilde{E}} \end{bmatrix} = \begin{bmatrix} \left. \frac{\partial \dot{\tilde{N}}}{\partial \tilde{N}} \right|_{\tilde{N}=\tilde{N}_{aso}} & \left. \frac{\partial \dot{\tilde{N}}}{\partial \tilde{E}} \right|_{E=E_{aso}} \\ \left. \frac{\partial \dot{\tilde{E}}}{\partial \tilde{N}} \right|_{\tilde{N}=\tilde{N}_{aso}} & \left. \frac{\partial \dot{\tilde{E}}}{\partial \tilde{E}} \right|_{E=E_{aso}} \end{bmatrix} \begin{bmatrix} \tilde{N} - \tilde{N}_{aso} \\ \tilde{E} - E_{aso} \end{bmatrix}$$

where

$$\begin{aligned} \left. \frac{\partial \dot{\tilde{N}}}{\partial \tilde{N}} \right|_{\tilde{N}=\tilde{N}_{aso}} &= \left( \frac{(1 + \eta - \mu(1 - \theta))(\phi + \beta)}{(1 - \theta)} + \frac{\phi\mu}{\eta - \mu(1 - \theta)} \right) m \frac{1 - Z}{Z} - \frac{\rho + m}{\eta - \mu(1 - \theta)} \\ \left. \frac{\partial \dot{\tilde{N}}}{\partial \tilde{E}} \right|_{E=E_{aso}} &= \left( \frac{m\psi\bar{z}^\mu\gamma_0^\mu}{\alpha} \frac{(\bar{E} - Z\bar{E})}{(Z\bar{E})^{\eta - \mu(1 - \theta + \phi)}} \right)^{\frac{1}{\eta - \mu(1 - \theta)}} \frac{m}{Z} \left( \frac{(1 + \phi\mu)(\phi + \beta)(1 - Z)}{(1 - \theta)} + \frac{\phi\mu}{\eta - \mu(1 - \theta)} \right) \\ \left. \frac{\partial \dot{\tilde{E}}}{\partial \tilde{N}} \right|_{\tilde{N}=\tilde{N}_{aso}} &= -(\eta - \mu(1 - \theta)) m \frac{1 - Z}{Z} \left( \frac{m\psi\bar{z}^\mu\gamma_0^\mu}{\alpha} \right)^{-\frac{1}{\eta - \mu(1 - \theta)}} \left( \frac{(\bar{E} - Z\bar{E})}{(Z\bar{E})^{\eta - \mu(1 - \theta + \phi)}} \right)^{-\frac{1}{\eta - \mu(1 - \theta)}} \\ \left. \frac{\partial \dot{\tilde{E}}}{\partial \tilde{E}} \right|_{E=E_{aso}} &= - \left( m - \mu\phi m \frac{1 - Z}{Z} \right) \end{aligned}$$

$$\text{And } Z = \frac{m\eta(\phi + \beta) - m\beta\mu(1 - \theta)}{(\rho + m)(1 - \theta) + m\eta(\phi + \beta) - m\beta\mu(1 - \theta)}.$$

After some tedious algebra we find that

$$\det J = \left( \left. \frac{\partial \dot{\tilde{N}}}{\partial \tilde{N}} \right|_{\tilde{N}=\tilde{N}_{aso}} \right) \left( \left. \frac{\partial \dot{\tilde{E}}}{\partial \tilde{E}} \right|_{E=E_{aso}} \right) - \left( \left. \frac{\partial \dot{\tilde{N}}}{\partial \tilde{E}} \right|_{E=E_{aso}} \right) \left( \left. \frac{\partial \dot{\tilde{E}}}{\partial \tilde{N}} \right|_{\tilde{N}=\tilde{N}_{aso}} \right) < 0$$

So the unique steady state is locally a saddle ■

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